Russian River Biological Opinion

Status and Data Report

Year 2012-2013

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1: Introduction

On September 24, 2008, the National Marine Fisheries Service (NMFS) issued a 15-year Biological Opinion for water supply, flood control operations, and channel maintenance conducted by the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (Water Agency), and Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed (NMFS 2008). The Biological Opinion authorizes incidental take of threatened and endangered Chinook salmon, coho salmon, and steelhead pending implementation of a Reasonable and Prudent Alternative (RPA) to status quo management of reservoir releases, river flow, habitat condition, and facilities in portions of the mainstem Russian River, Dry Creek, and Russian River Estuary. Mandated projects to ameliorate impacts to listed salmonids in the RPA are partitioned among USACE and the Water Agency. Each organization has its own reporting requirements to NMFS. Because coho salmon are also listed as endangered by the California Endangered Species Act (CESA), the Water Agency is party to a Consistency Determination issued by the California Department of Fish and Wildlife (CDFW) in November 2009. The Consistency Determination mandates that the Water Agency implement a subset of Biological Opinion projects that pertain to coho and the Water Agency is required to report progress on these efforts to CDFW.

Project implementation timelines in the Biological Opinion, and Consistency Determination, specify Water Agency reporting requirements to NMFS and CDFW and encourage frequent communication among the agencies. The Water Agency has engaged both NMFS and CDFW in frequent meetings and has presented project status updates on many occasions since early 2009. Although not an explicit requirement of the Biological Opinion or Consistency Determination, the Water Agency has elected to coalesce reporting requirements into one annual volume for presentation to the agencies. The following document represents the fourth report for year 2012-2013. Previous annual reports can be accessed at http://www.scwa.ca.gov.

Water Agency projects mandated by the Biological Opinion and Consistency Determination fall into six major categories:

- Biological and Habitat Monitoring;
- Habitat Enhancement;
- California Environmental Quality Act (CEQA) Compliance and Permitting;
- Planning and Adaptive Management;
- Water and Fish Facilities Improvements; and

- Public Outreach.

This report contains status updates for planning efforts, environmental compliance, and outreach but the majority of the technical information we present pertains to monitoring and habitat enhancement. The Biological Opinion requires extensive fisheries data collection in the mainstem Russian River, Dry Creek, and Estuary to detect trends and inform habitat enhancement efforts. The report presents each data collection effort independently and the primary intent of this document is to clearly communicate recent results. However, because Chinook, coho, and steelhead have complex life history patterns that integrate all of these environments, we also present a synthesis section to discuss the interrelated nature of the data. Some monitoring programs are extensions of ongoing Water Agency efforts that were initiated a decade or more before receipt of the Biological Opinion.

References

National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed. September 24, 2008.

2: Public Outreach

Biological Opinion Requirements

The Biological Opinion includes minimal *explicit* public outreach requirements. The breadth and depth of the RPAs, however, *implies* that implementation of the Biological Opinion will include a robust public outreach program.

RPA 1 (Pursue Changes to D1610 Flows) mandates two outreach activities. First, it requires the Water Agency, with the support of NMFS staff, to conduct outreach "to affected parties in the Russian River watershed" regarding permanently changing Decision 1610. Second, the RPA requires the Water Agency to update NMFS on the progress of temporary urgency changes to flows during Section 7 progress meetings and as public notices and documents are issued.

RPA 2 (Adaptive Management of the Outlet Channel) requires that within six months of the issuance of the Biological Opinion the Water Agency, in consultation with NMFS, "conduct public outreach and education on the need to reduce estuarine impacts by avoiding mechanical breaching to the greatest extent possible."

Finally, RPA 3 (Dry Creek Habitat Enhancements, refers to public outreach in the following mandate, "Working with local landowners, DFG[1] and NMFS, Water Agency will prioritize options for implementation" of habitat enhancement.

The remaining RPAs do not mention public outreach.

Water Agency Public Outreach Activities – 2012/2013

Meetings

Public Policy Facilitating Committee (PPFC) meeting - The PPFC met in December 2012 for an update of the year's activities. Notices for the meeting were sent out to approximately 800 individuals and agencies and a press release was issued. Approximately 80 people attended the meeting and heard presentations from Dr. Bill Hearn, NMFS, Eric Larson, CDFW, Mike Dillabough, USACE and, from the Water Agency, Jessica Martini Lamb, Chris Delaney, Justin Smith, Gregg Horton, Dave Manning, Dave Cuneo, Jim Flugum, and Pam Jeane.

Community Meetings, Events & Tours – No meetings were held regarding the Estuary in 2012 because of litigation regarding the Russian River Estuary Management Project Environmental Impact Report (EIR). There were no meetings held regarding the Fish Flow Project, as Water Agency staff worked internally on modeling and analysis.

A community meeting on Dry Creek habitat enhancement was held in June 2013 in the Lake Sonoma Visitors Center. The meeting was co-hosted by the Dry Creek Valley

[1] DFG (Department of Fish and Game) is now known as the California Department of Fish and Wildlife.

Association, the Winegrape Growers of Dry Creek, the USACE and the Water Agency. About 50 people attended to hear about construction plans for summer 2013 and identification of Miles 2 and 3.

Several tours and events were held in Dry Creek. The USACE and the Water Agency co-hosted a ribbon-cutting at the new building housing the Russian River Coho Salmon Captive Broodstock Program on May 2, 2012. Approximately 75 people attended, including Representative Mike Thompson, Sonoma County Supervisors Efren Carrillo, Mike McGuire, David Rabbitt and Shirlee Zane. Several legislative staff and representatives from NMFS, CDFG, and the Corps were present, as were nonprofit partners and members of the public.

The USACE and the Water Agency co-hosted a Golden Shovel event at the Corps Dry Creek Demonstration project in October 2012. Approximately 50 people attended and many accompanied Water Agency staff on a tour of the Quivira demonstration project.

The USACE and the Water Agency co-hosted a coho release celebration at the Corps Dry Creek Demonstration project in November 2013. Approximately 75 people attended, including members of the press, Lt. Col John Baker, representatives from several water contractors, members of the Dry Creek Band of Pomo Indians, staff from National Marine Fisheries Service and the California Department of Fish and Wildlife and the Friends of Lake Sonoma. Several people accompanied Water Agency staff on a tour of the Dry Creek Vineyard demonstration project.

Several tours were held for public officials in 2012 and 2013 of the Coho Broodstock Program and of Dry Creek habitat enhancement sites. NMFS, DFG, Corps and Water Agency staff worked together on these tours, which included: NOAA Director Dr. Jane Lubchenco; Representative Mike Thompson; Assembly Member Wes Chesbro; Assembly Member Marc Levine; the Director of California's Department of Conservation, Mark Nechodem; California Senate Natural Resources Committee staff member Bill Craven; NOAA's Director of the Office of Habitat Restoration Buck Sutter; State Water Resources Control Board member Steve Moore; the Water Advisory Committee and Technical Advisory Committee; Valley of the Moon Water District Board of Directors; Nature Conservancy staff; staff of the State Water Resources Control Board, and CalTrout.

Stakeholder Process

The Dry Creek Advisory Group (Advisory Group), created in 2009, is a stakeholder group comprised of landowners and representatives from the Water Agency, the USACE, NMFS and CDFW. From 2009 through 2011, the Advisory Group met regularly to review draft documents and discuss potential project plans. As project activities began to shift toward construction and implementation, Advisory Group meetings shifted focus to touring completed projects and receiving updates regarding future habitat enhancement activities.

While no meetings of the Advisory Group took place in 2012, the Advisory Group met on April 3, 2013 for a tour of the completed habitat enhancement projects at Quivira Vineyards & Winery and Grape Creek. In 2014, the Advisory Group will be invited to tour the work completed in 2013 at Dry Creek Vineyard and Amista Vineyards.

Other Outreach

Free Media – Several articles about the Biological Opinion appeared during 2012 and 2013 in The Press Democrat, the Russian River Times, the West County News and Review, and North Bay Bohemian, the Russian River Gazette and on Bay Area television stations 4, 5 and 7. In 2012, press releases were issued on a NFWF grant for fish studies in the Russian River, board approval of the Dry creek Habitat Enahncement Project and environmental documentation for the project, the start of construction for the Quivira component of Dry creek habitat enhancement, the Corps appropriations for Dry creek habitat enhancement, the coho broodstock building completion, temporary urgency changes, Mirabel fish screen environmental documents, Chinook returns and two Public Policy Facilitating Committee meetings. In 2013, press releases were issued on a Department of Fish and Wildlife grant for the Mirabel fishway improvements, Dry Creek habitat construction, community meetings regarding the estuary and Dry Creek, Chinook returns, coho releases and the Public Policy Facilitating Committee meeting.

Electronic Media – The Water Agency continually updated its Biological Opinion webpage, including links on new documents and meetings. In addition, the Water Agency posted videos on YouTube regarding Chinook returns, Dry Creek winter backwater, the Grape Creek fish passage project and Dry Creek habitat construction, which can be accessed via the agency's website. Email alerts regarding activities in the estuary were issued about a dozen times per year in 2012 and 2013.

Materials – In 2012, the Water Agency rewrote and redesigned its briefing papers to reflect new information and studies being conducted. A jetty FAQ was developed, along with a Dry Creek Demonstration Project flyer. These materials were distributed at meetings, conferences, statewide forums, outreach events and through the Water Agency website. In addition, a simple postcard handout was developed for events geared to the general public. A flyer was mailed to all Dry Creek Valley residents informing them of the demonstration projects being conducted by the Water Agency and the Corps. In 2013, the flyer regarding the Dry Creek Demonstration Project was updated several times to reflect different stages of construction and a flyer was developed on the Mirabel fish screen/fish ladder project. Other materials were updated and distributed at meetings, conferences, statewide forums, outreach events and through the Water Agency website.

Sonoma County Fair – The Biological Opinion was the focus of the Water Agency's outreach efforts at the Sonoma County Fair in 2012. In order to get a free gift, attendees needed to take a short "quiz" focused on aspects of the Biological Opinion (questions included "Name one of three fish in the Russian River that is on the endangered species list?” “Why are we asking people to conserve water this summer, even though we aren’t in a drought?” “Why is Dry Creek important to your water supply?” and “Can you tell us what an estuary is and whether the Russian River has one?”). These questions provided staff an opportunity to discuss the Biological Opinion with approximately 4,000 people.

3: Pursue Changes to Decision 1610 Flows

Two major reservoir projects provide water supply storage in the Russian River watershed: 1) Coyote Valley Dam/Lake Mendocino, located on the East Fork of the Russian River three miles east of Ukiah, and 2) Warm Springs Dam/Lake Sonoma, located on Dry Creek 14 miles northwest of Healdsburg. The Water Agency is the local sponsor for these two federal water supply and flood control projects, collectively referred to as the Russian River Project. Under agreements with the USACE, the Water Agency manages the water supply storage space in these reservoirs to provide a water supply and maintain summertime Russian River and Dry Creek streamflows.

The Water Agency holds water-right permits[2] issued by the State Water Resources Control Board (SWRCB) that authorize the Water Agency to divert[3] Russian River and Dry Creek flows and to re-divert[4] water stored and released from Lake Mendocino and Lake Sonoma. The Water Agency releases water from storage in these lakes for delivery to municipalities, where the water is used primarily for residential, governmental, commercial, and industrial purposes. The primary points of diversion include the Water Agency's facilities at Wohler and Mirabel Park (near Forestville). The Water Agency also releases water to satisfy the needs of other water users and to contribute to the maintenance of minimum instream flow requirements in the Russian River and Dry Creek established in 1986 by the SWRCB's Decision 1610. These minimum instream flow requirements vary depending on specific hydrologic conditions (normal, dry, and critical) that are based on cumulative inflows into Lake Pillsbury in the Eel River watershed.

NMFS concluded in the Russian River Biological Opinion that the artificially elevated summertime minimum flows in the Russian River and Dry Creek currently required by Decision 1610 result in high water velocities that reduce the quality and quantity of rearing habitat for coho salmon and steelhead. NMFS' Russian River Biological Opinion concludes that reducing Decision 1610 minimum instream flow requirements will enable alternative flow management scenarios that will increase available rearing habitat in Dry Creek and the upper Russian River, and provide a lower, closer-to-natural inflow to the estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon.

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[2] SWRCB water-right permits 12947A, 12949, 12950 and 16596.

[3] Divert – refers to water diverted directly from streamflows into distribution systems for beneficial uses or into storage in reservoirs.

[4] Re-divert – refers to water that has been diverted to storage in a reservoir, then is released and diverted again at a point downstream.

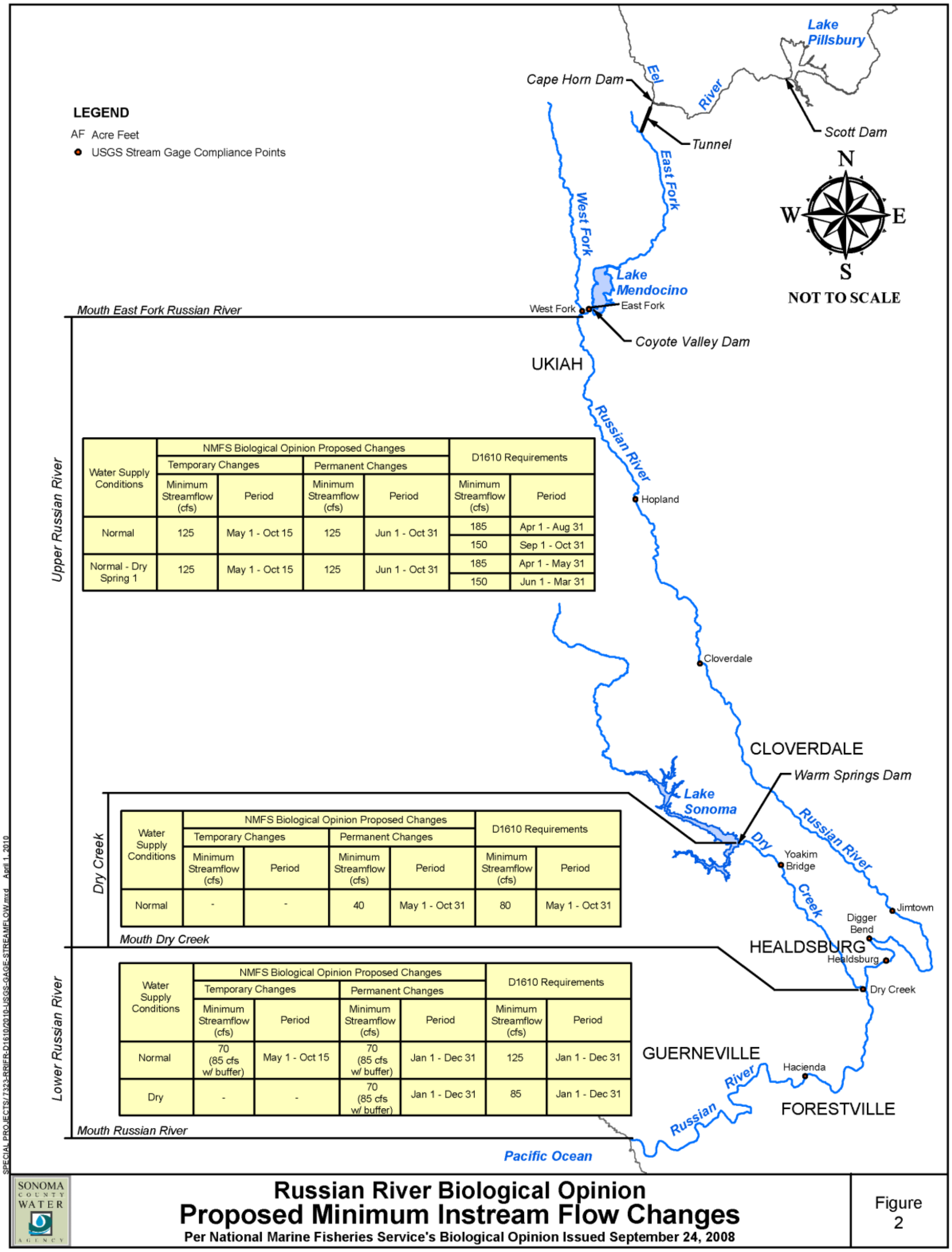
Changes to Decision 1610 are under the purview of the SWRCB, which retained under Decision 1610 the jurisdiction to modify minimum instream flow requirements if future fisheries studies identified a benefit. NMFS recognized that changing Decision 1610 would require a multi-year (6 to 8 years) process of petitioning the SWRCB for changes to minimum instream flow requirements, public notice of the petition, compliance with CEQA, and a SWRCB hearing process. To minimize the effects of existing minimum instream flows on listed salmonids during this process, the Russian River Biological Opinion stipulated that the Water Agency "will seek both long term and interim changes to minimum flow requirements stipulated by D1610." The permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion are summarized in Figure 3.1.

Permanent Changes

The Russian River Biological Opinion requires the Water Agency to begin the process of changing minimum instream flows by submitting a petition to change Decision 1610 to the SWRCB within one year of the date of issuance of the final Biological Opinion. The Water Agency filed a petition with the SWRCB on September 23, 2009, to permanently change Decision 1610 minimum instream flow requirements. The requested changes are to reduce minimum instream flow requirements in the mainstem Russian River and Dry Creek between late spring and early fall during normal and dry water years and promote the goals of enhancing salmonid rearing habitat in the upper Russian River mainstem, lower river in the vicinity of the Estuary, and Dry Creek downstream of Warm Springs Dam. NMFS' Russian River Biological Opinion concluded that, in addition to providing fishery benefits, the lower instream flow requirements "should promote water conservation and limit effects on in-stream river recreation." NMFS stated that the following changes, based on observations during the 2001 interagency flow-habitat study and the 2007 low flow season, may achieve these goals:

During Normal Years:

1. Reduce the minimum flow requirement for the Russian River from the East Fork to Dry Creek from 185 cubic-feet per second (cfs) to 125 cfs between June 1 and August 31; and from 150 cfs to 125 cfs between September 1 and October 31.
2. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 125 cfs to 70 cfs.
3. Reduce the minimum flow requirement for Dry Creek from Warm Springs Dam to the Russian River from 80 cfs to 40 cfs from May 1 to October 31.



Upper Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Period	Permanent Changes – Minimum Streamflow (cfs)	Period	D1610 Requirements – Minimum Streamflow (cfs)	Period
Normal	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - Aug 31
					150	Sep 1 - Oct 31
Normal - Dry Spring 1	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - May 31
					150	Jun 1 - Mar 31

Dry Creek

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Period	Permanent Changes – Minimum Streamflow (cfs)	Period	D1610 Requirements – Minimum Streamflow (cfs)	Period
Normal	-	-	40	May 1 - Oct 31	80	May 1 - Oct 31

Lower Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Period	Permanent Changes – Minimum Streamflow (cfs)	Period	D1610 Requirements – Minimum Streamflow (cfs)	Period
Normal	70 (85 cfs w/ buffer)	May 1 - Oct 15	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	125	Jan 1 - Dec 31
Dry	-	-	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	85	Jan 1 - Dec 31

Figure 3.1. A summary of the permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion.

During Dry Years:

1. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 85 cfs to 70 cfs.

Summary Status

The SWRCB issued a second amended public notice of the Water Agency's petition to modify Decision 1610 for public comment on March 29, 2010. Following filing of the petition to change Decision 1610, the Water Agency issued a Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the Fish Habitat Flows and Water Rights Project (Fish Flow Project). Comments received during the NOP scoping process are being considered during current preparation of the Fish Flow Project Draft EIR.

Temporary Changes

Until the SWRCB issues an order on the petition to permanently modify Decision 1610, the minimum instream flow requirements specified in Decision 1610 (with the resulting adverse impacts to listed salmonids) will remain in effect, unless temporary changes to these requirements are made by the SWRCB. The Russian River Biological Opinion requires that the Water Agency petition the SWRCB for temporary changes to the Decision 1610 minimum instream flow requirements beginning in 2010 and for each year until the SWRCB issues an order on the Water Agency's petition for the permanent changes to these requirements. NMFS' Russian River Biological Opinion only requires that petitions for temporary changes "request that minimum bypass flows of 70 cfs be implemented at the USGS gage at the Hacienda Bridge between May 1 and October 15, with the understanding that for compliance purposes SCWA will typically maintain about 85 cfs at the Hacienda gage. For purposes of enhancing steelhead rearing habitats between the East Branch and Hopland, these petitions will request a minimum bypass flow of 125 cfs at the Healdsburg gage between May 1 and October 15."

Summary Status

The Water Agency petitioned the SWRCB for temporary changes to Decision 1610 on April 5, 2012 (Appendix A-1). The Water Agency filed a Temporary Urgency Change Petition (TUCP) to request that the SWRCB reduce the minimum instream flow requirements for the Russian River in the Water Agency's water-right permits in accordance with the recommendations in the Russian River Biological Opinion.

The Water Agency requested that the SWRCB make the following temporary changes to the Decision 1610 instream flow requirements:

- From May 1 through October 15, 2012, minimum instream flow requirements for the upper Russian River (from the confluence with the East Fork of the Russian River to its Confluence with Dry Creek) be reduced from 185 cfs to 125 cfs.

- From May 1 through October 15, 2012, minimum instream flow requirements for the lower Russian River (downstream of its confluence with Dry Creek) be reduced from

125 cfs to 70 cfs with the understanding the Water Agency will typically maintain approximately 85 cfs at the Hacienda Gauge as practicably feasible.

The SWRCB issued a public notice of the Water Agency's petition on April 25, 2012 (Appendix A-2). The SWRCB issued an Order approving the Water Agency's TUCP on May 2, 2012 (Appendix A-3). The order included several terms and conditions, including requirements for fisheries habitat monitoring (Terms 2 to 7), preparation of a water quality monitoring plan and summary data report (Terms 8 and 9), contining to work with agricultural Russian River water users to pursue opportunities that would result in improved management of the Russian River by better anticipating periods of high water demand (Term 12), reporting of activities and programs implemented by the Water Agency and its contractors to assess and reduce water loss and promote increasing water use efficiency (Term 13), and updating the SWRCB on the progress of the Santa Rosa Plain Groundwater Management Planning Program (Term 14). Reports to fulfill the terms of the order were prepared and submitted to the SWRCB and are provided in Appendices A-4 through A-7.

Provisions 2 through 7 of the State Water Board Order required the Water Agency to conduct and report on a number of fisheries monitoring projects. The Water Agency and SWRCB consulted with NMFS and CDFW regarding the fisheries monitoring objectives and methods. Projects included monitoring adult Chinook salmon returns at the Mirabel inflatable dam, dive surveys to monitor Chinook in the lower and upper Russian River, dive surveys to measure the relative abundance of juvenile steelhead and native freshwater fish in the upper Russian River, and salmonid downstream migrant trapping operations in Dry Creek, the mainstem of the Russian River at Mirabel Dam and the Russian River estuary near Duncans Mills. Updates of fisheries monitoring data were sent to NMFS and CDFW staff every two weeks per provision 7 of the State Water Board Order. While not a provision of the SWRCB Order, the Biological Opinion requires fish trap data collection in Austin Creek, Dutchbill Creek, and Mark West Creek. Detailed results are provided in the *Results of the Fisheries Monitoring Plan for the Sonoma County Water Agency 2012 Temporary Urgency Change* (Appendix A-4). Additional analysis of fisheries habitat related to changes in minimum instream flows are provided in the water quality summary data report in Appendix A-6.

Water samples were collected from the following six (6) surface-water sites in the mainstem of the Russian River: Hopland; Comminsky Station; Jimtown Bridge; Diggers Bend; Riverfront Park; and Hacienda.

All samples were analyzed for nutrients, chlorophyll *a*, standard bacterial indicators (total coliforms, *E. coli* and enterococci), total and dissolved organic carbon, turbidity, and total dissolved solids. Samples were not analyzed specifically for total coliforms, but concentrations are determined as part of the analytical process for determining *E. coli* concentrations and the results are included in the lab report. As such, it should be noted that the dilution rates that are utilized to accurately quantify *E. coli* concentrations for comparison to the draft guidelines do not allow for the quantification of total coliform concentrations at a high enough level to compare with the draft guidelines and are instead reported as greater than 2419.6 MPN (>2419.6). The decision to focus on *E. coli* and enterococcus for the analysis of potential water quality impacts and not total coliform concentrations was done in coordination and consultation with North Coast Regional Water Quality Control Board staff. Duplicate samples of all constituents were taken at Hacienda, and triplicate samples were taken for bacteria at Hacienda and Jimtown Bridge.

Bacteria analysis for the Water Agency was conducted by the Sonoma County DHS Public Health Division Lab in Santa Rosa. *E. coli* and total coliform were analyzed using the Colilert method and enterococcus was analyzed using the Enterolert method.

Monitoring results were posted to the Water Agency website and are provided in Appendix A-6. Water quality monitoring in the Russian River Estuary is further discussed in Chapter 4.

4: Estuary Management

The Russian River estuary (Estuary) is located approximately 97 kilometers (km; 60 miles) northwest of San Francisco in Jenner, Sonoma County, California. The Estuary extends from the mouth of the Russian River upstream approximately 10 to 11 km (6 to 7 miles) between Austin Creek and the community of Duncans Mills (Heckel 1994). When a barrier beach forms and closes the river mouth, a lagoon forms behind the beach and reaches up to Vacation Beach.

The Estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. The mouth is located at Goat Rock State Beach (California Department of Parks and Recreation). Although closures may occur at anytime of the year, the mouth usually closes during the spring, summer, and fall (Heckel 1994; Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma County Water Agency and Merritt Smith Consulting 2001). Closures result in ponding of the Russian River behind the barrier beach and, as water surface levels rise in the Estuary, flooding may occur. The barrier beach has been artificially breached for decades; first by local citizens, then the County of Sonoma Public Works Department, and, since 1995, by the Water Agency. The Water Agency's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the estuary.

NMFS' Russian River Biological Opinion (NMFS 2008) found that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historic artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat for steelhead, coho salmon, and Chinook salmon. The historical method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the estuary's water quality and freshwater depths. The historical artificial breaching practices create a tidal marine environment with shallow depths and high salinity. Salinity stratification contributes to low dissolved oxygen at the bottom in some areas. The Biological Opinion (NMFS 2008) concludes that the combination of high inflows and breaching practices impact rearing habitat because they interfere with natural processes that cause a freshwater lagoon to form behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's RPA 2, Alterations to Estuary Management, (NMFS 2008) requires the Water Agency to collaborate with NMFS and to modify estuary water level management in order to reduce marine influence (high salinity and tidal inflow) and promote a higher water surface elevation in the estuary (formation of a fresh or brackish lagoon) for purposes of enhancing the quality of rearing habitat for young-of-year and age 1+ juvenile (age 0+ and 1+) steelhead from May 15 to October 15 (referred to hereafter as the “lagoon management period”). A program of potential, incremental steps are prescribed to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach, study of the existing jetty and its potential influence on beach formation processes and salinity seepage through the barrier beach, and a feasibility study of alternative flood risk measures. RPA 2 also includes provisions for monitoring the response of water quality, invertebrate production, and salmonids in the estuary to the management of water surface elevations during the lagoon management period.

The following section provides a summary of the Water Agency’s estuary management actions required under the Russian River Biological Opinion RPA 2 in 2012.

Sandbar Management

RPA 2 requires the Water Agency, in coordination with NMFS, CDFW, and the USACE, to annually prepare barrier beach outlet channel design plans. Each year after coordinating with the agencies, the Water Agency is to provide a draft plan to NMFS, CDFW, and the USACE by April 1 for their review and input. The initial plan was to entail the design of a lagoon outlet channel cut diagonally to the northwest. Sediment transport equations shall be used by Water Agency as channel design criteria to minimize channel scour at the anticipated rate of Russian River discharge. This general channel design will be used instead of traditional mechanical breaching whenever the barrier beach closes and it is safe for personnel and equipment to work on the barrier beach. Alternate methods may include 1) use of a channel cut to the south if prolonged south west swells occur, and 2) use of the current jetty as a channel grade control structure (as described below) for maintaining water surface elevations up to 7-9 feet NGVD (NMFS 2008).

The Water Agency contracted with Environmental Science Associates (ESA PWA, formerly Philip Williams and Associates) to prepare the Russian River Estuary Outlet Channel Adaptive Management Plan (Appendix B-1). The approach of the plan was to meet the objective of RPA 2 to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic, biological, and recreational resources of the site. It was recognized that the measures developed in the management plan, when implemented, potentially could not fully meet the objectives established by the RPA. The concept of this approach was developed in coordination with NMFS, CDFW, and California State Parks.

A monthly topographic survey of the beach at the mouth of the Russian River is also required under RPA 2. Topographic data was not collected in December 2012 as weather and beach conditions did not allow for safe beach access. The beach topographic maps are provided in Appendix B-2.

During the 2012 management period, May 15th to October 15th, Water Agency staff regularly monitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although the inlet experienced several closures, none resulted in water levels above 5.5 ft NGVD prior to self-breaching. For much of June and July, the inlet was either closed or only allowing heavily muted tides (tide range < 1 ft), but the lagoon water surface never surpassed 5 ft NGVD. During this time, each closure ended when lagoon water levels increased, overtopped the beach berm, and scoured a new tidal channel. Since these episodes did not evolve to the point that management action was warranted, the Water Agency did not take any management actions to encourage formation of an outlet channel. For the remainder of July, all of August, and the first half of September, the estuary was fully tidal. Then the inlet closed twice between September 20th and October 10th. Both closures were shortlived, lasting less than one week, and again the inlet self-breached, precluding any Water Agency management action. The highest lagoon water level of the 2012 management period, 5.25 ft NGVD, occurred at the end of the October closure (ESA PWA 2013).

Jetty

RPA 2 includes a second step if adaptive management of the outlet channel as described, "is not able to reliably achieve the targeted annual and seasonal estuary management water surface elevations by the end of 2010, Water Agency will draft a study plan for analyzing the effects and role of the Russian River jetty at Jenner on beach permeability, seasonal sand storage and transport, seasonal flood risk, and seasonal water surface elevations in the Russian River estuary. That study will also evaluate alternatives for achieving targeted estuarine management water surface elevations via jetty removal, partial removal of the jetty, jetty notching, and potential use of the jetty as a tool in maintaining the estuary water surface elevations described above."

ESA PWA, at the request of the Water Agency, developed a plan to study the effects of the Goat Rock State Beach jetty on the Estuary in 2011 (ESA PWA 2011). In addition, it described the recommended approach for developing and assessing the feasibility of alternatives to the existing jetty that may help achieve target estuarine water surface elevations. As such, this study plan fulfills a portion of the Water Agency's obligations under the Biological Opinion. The Biological Opinion directs the Water Agency to change its management of the Estuary's water surface elevations with the intent of improving juvenile salmonid habitat while minimizing flood risk. A draft existing conditions report was provided to NMFS and CDFW with analysis including historic information on the jetty's construction, ocean waves, inlet and beach morphology conditions (Appendix B-3).

Flood Risk Management

RPA 2 also includes a Flood Risk Reduction step if it proves difficult to reliably achieve raised water surface elevation targets based on implementation of a lagoon outlet channel or modification of the existing jetty. Should those actions be unsuccessful in meeting estuarine water surface elevation goals, RPA 2 states that the Water Agency "will evaluate, in coordination with NMFS and other appropriate public agencies, the feasibility of actions to avoid or mitigate damages to structures in the town of Jenner and low-lying properties along the estuary that are currently threatened with flooding and prolonged inundation when the barrier beach closes and the estuary's water surface elevation rises above 9 feet. Such actions may include, but are not limited to, elevating structures to avoid flooding or inundation."

The first effort to address flood risk management feasibility was compilation of a preliminary list of structures, properties, and infrastructure that would be subject to flooding/inundation as the result of sandbar formation and if the estuary were allowed to naturally breach. As required by RPA 2 in the Russian River Biological Opinion, the Water Agency submitted a preliminary list of properties, structures, and infrastructure that may be subject to inundation if the barrier beach at the mouth of the Russian River was allowed to naturally breach. This preliminary list was updated for the California Coastal Commission Coastal Development Permit application process and is included here (Appendix B-4). Allowing Estuary water surface elevations to rise to between 10 and 12 feet NGVD (the estimated water surface elevation if the barrier beach was allowed to naturally breach per consultation with NMFS) may potentially inundate portions of up to 97 properties.

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4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River Estuary, including two tributaries and the maximum backwater area, between the mouth of the river at Jenner and Monte Rio. Water Agency staff continued to collect data to establish baseline information on water quality in the Estuary, gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, and track changes to the water quality profile that may occur during periods of barrier beach closure, partial or full lagoon formation, lagoon outlet channel implementation, and sandbar breach.

Saline water is denser than freshwater and a salinity “wedge” (halocline) forms in the Estuary as freshwater outflow passes over the denser tidal inflow. During the Lagoon Management Period, the lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream to Duncans Mills during summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the reaches of the Estuary. The maximum backwater area encompasses the area of the river between Duncans Mills and Monte Rio that is generally outside the influence of saline water, but within the upper extent of inundation and backwatering that can occur during tidal cycles and lagoon formation.

In 2012, the Estuary did not experience any significant closures during the lagoon management period, however there were several periods of muted tides and perched conditions resulting in partial lagoon formation. Perched conditions occur when a barrier beach is incompletely formed and a small outlet channel may remain, thus allowing water levels to rise while still providing outflow from the river at a lower water surface elevation. Perched conditions occurred six (6) times during the lagoon management period and twice more in the month of November. Perched conditions were generally short-lived, occurring in pairs, and were often preceeded or followed by muted tidal conditions. Perched conditions were observed for four days from 11 June to 14 June and eight days from 16 June to 23 June; and then for six days from 7 July to 12 July and nine days from 12 July to 20 July. Later in the season, perched conditions occurred for six days from 29 September to 4 October and ten days from 7 October to 16 October. Finally, perched conditions were observed outside the lagoon management period for five days from 4 November to 8 November and four days from 9 November to 12 November. During this time the Water Agency was able to monitor the partial development of a freshwater lagoon system as freshwater inflows increased the surface layer. The estuary also experienced several extended periods of muted tidal cycles, primarily in May and June, whereby the opening at the river mouth was somewhat isolated from ocean swells by the Jetty, resulting in significantly reduced tidal action and salinity migration into and out of the estuary.

Methods

Continuous Multi-Parameter Monitoring

Water quality was monitored using YSI Series 6600 multi-parameter datasondes. Hourly salinity (parts per thousand), water temperature (degrees Celsius), dissolved oxygen (percent saturation), dissolved oxygen (milligrams per liter), and pH (hydrogen ion) data were collected. Datasondes were cleaned and recalibrated periodically following the YSI User Manual procedures, and data was downloaded during each calibration event.

Ten stations were established for continuous water quality monitoring, including eight stations in the mainstem and two tributary stations (Figure 4.1.1). One mainstem station was located in the lower reach at the mouth of the Russian River at Goat Rock State Beach (Mouth Station). Two mainstem stations were placed in the middle reach: Patty's Rock upstream of Penny Island (Patty's Rock Station); and in the pool downstream of Sheephouse Creek (Sheephouse Creek Station). One tributary station was located in the mouth of Willow Creek, which flows into the middle reach of the estuary (Willow Creek Station). Three mainstem stations were located in the upper reach; a pool next to an area known as Heron Rookery located halfway between Sheephouse Creek and Duncans Mills (Heron Rookery Station), downstream of Freezeout Creek in Duncans Mills (Freezeout Creek Station), and downstream of Austin Creek in Brown's Pool (Brown's Pool Station). The other tributary station was located downstream of the first steel bridge in lower Austin Creek, which flows into the mainstem above Brown's Pool Station. Finally, two mainstem stations were located in the maximum backwater area; a pool downstream of the community of Villa Grande (Villa Grande Station) and in Monte Rio (Monte Rio Station).

The rationale for choosing mainstem Estuary sites, including the Brown's Pool Station, was to locate the deepest holes at various points throughout the Estuary to obtain the fullest vertical profiles possible and to monitor salinity circulation and stratification, hypoxic and/or anoxic events, and temperature stratification. Sondes were located near the mouths of Willow and Austin Creeks to collect baseline water quality conditions and monitor potential changes to water quality (e.g salinity intrusion) resulting from tidal cycling or inundation during partial or full lagoon formation. The Villa Grande and Monte Rio stations were established to monitor potential changes to water quality conditions in the maximum backwater area while inundated during lagoon formation (Figure 4.1.1). The Villa Grande Station was also placed at the bottom of a deep hole to collect baseline data on hypoxic and/or anoxic events, and determine whether temperature stratification occurs or cold water refugia is present.

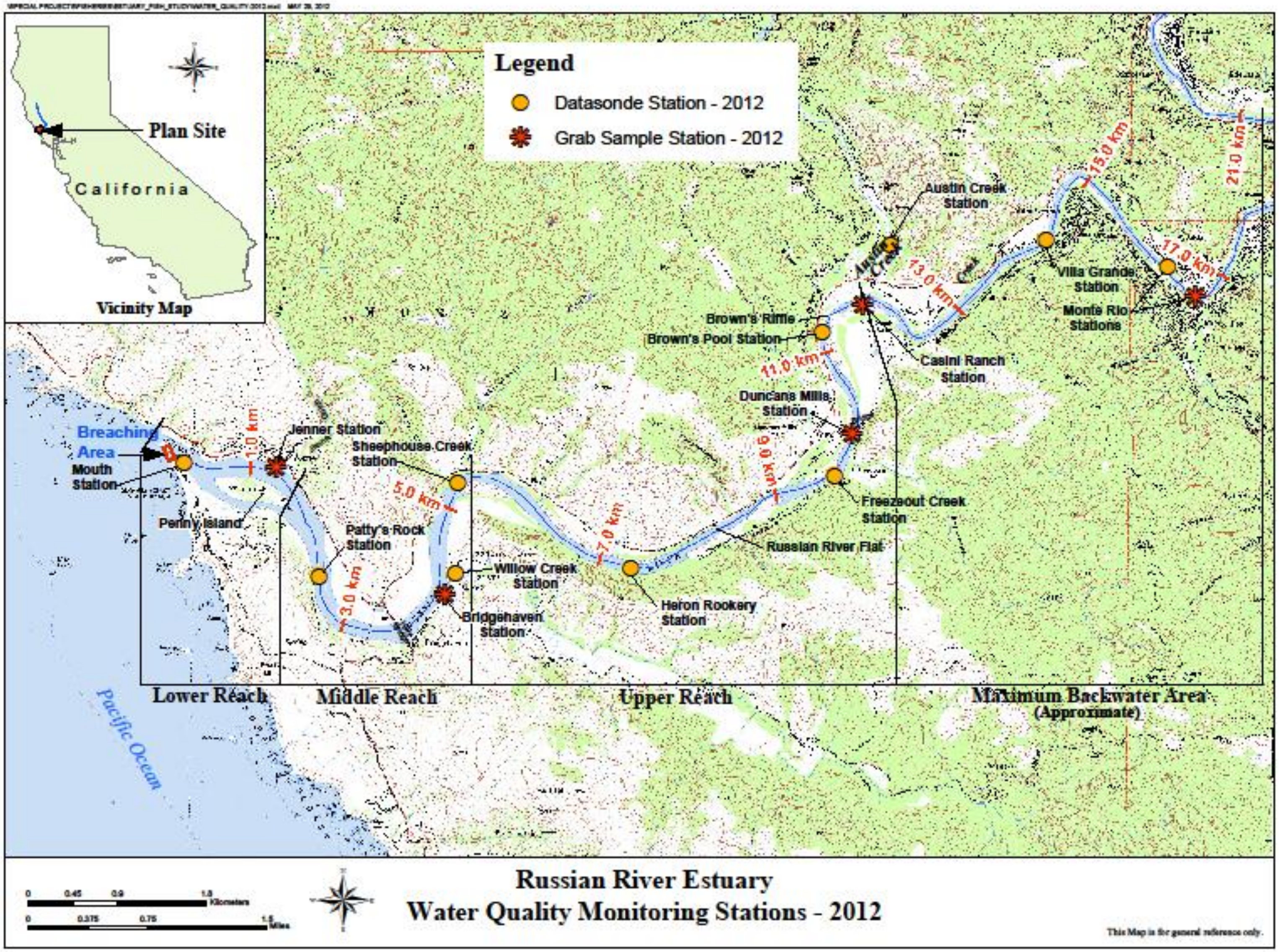

Figure 4.1.1. 2012 Russian River estuary water quality monitoring stations.

Mainstem estuary monitoring stations up to Freezeout Creek were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2). The Mouth, Patty's Rock, and Heron Rookery stations had a vertical array of two datasondes to collect water quality profiles, whereas the Sheephouse Creek and Freezeout Creek stations had one each. Stations in the lower and middle reaches of the Estuary that are predominantly saline had sondes placed at the surface (~1m) and/or mid-depth (~3m) portions of the water column.

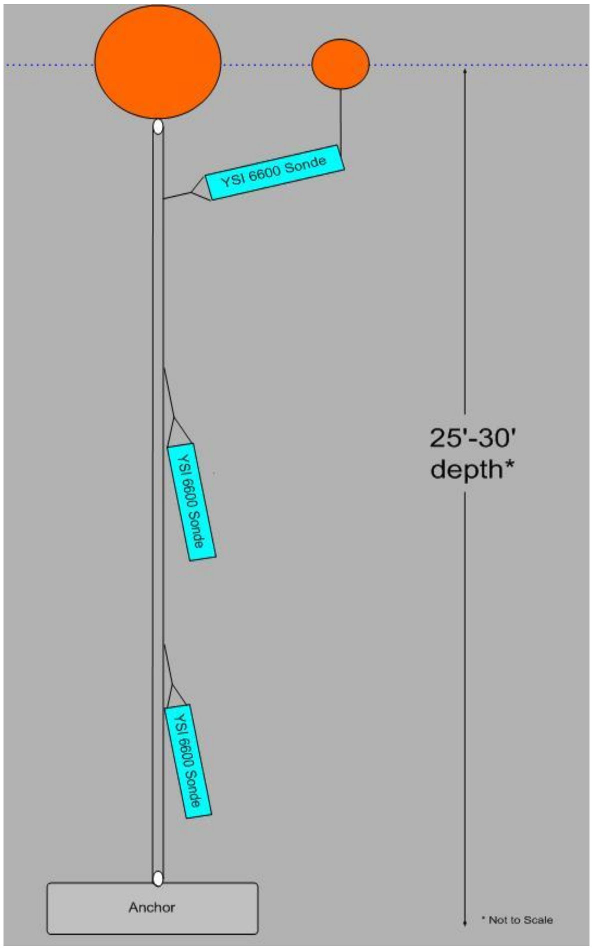

Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

The two stations in the upper reach of the Estuary, where water is predominantly fresh to brackish, had sondes located in the lower half of the water column at mid-depth (~4-5m) and the bottom (~6-9m). Sondes were located in this manner to track vertical and longitudinal changes in water quality characteristics during periods of tidal circulation, barrier beach closure, lagoon formation, lagoon outlet channel implementation, and sandbar breach.

The monitoring station in the Maximum Backwater Area at Villa Grande was placed at the bottom of a deep pool (~6-8m), whereas the monitoring stations in Austin Creek and at Monte Rio consisted of one datasonde suspended at approximately mid-depth (during open conditions) in the thalweg at each respective site.

All stations, except the Freezeout Creek Station, were initially deployed between mid-April and mid-May. The Freezeout Creek station was deployed in early August due to equipment malfunction. With the exception of the Willow Creek Station, the station datasondes were retrieved between late October and mid-November ahead of winter rain events. The Willow Creek station was left in to conduct year-round monitoring. The Brown's Pool station was not deployed in 2012 due to a lack of functioning equipment.

Grab Sample Collection

In 2012, Water Agency staff continued to conduct nutrient and indicator bacteria grab sampling at the five stations established in 2010: the Jenner Boat Ramp (Jenner Station); Bridgehaven at the mouth of Willow Creek (Bridgehaven Station); Moscow Road Bridge in Duncans Mills (Duncans Mills Station); Casini Ranch across from the mouth of Austin Creek (Casini Ranch Station); and just downstream of the Monte Rio Bridge (Monte Rio Station). Water Agency staff also collected duplicate samples for non-bacterial parameters and triplicate samples for bacterial indicators at the Monte Rio Station during the monitoring period. Refer to Figure 4.1.1 for grab sampling locations.

Water Agency staff collected grab samples once every two weeks from 22 May to 17 July, until flows measured at USGS gaging station 11467000 (Hacienda) were consistently below 125 cfs, and then samples were collected weekly through the rest of the season. Additional focused sampling (collecting three samples over a ten-day period) was conducted following or during specific river management and operational events including: barrier beach closure, lagoon outlet channel implementation, artificial breach, or removal of lower Russian River summer recreational dams. All grab samples were analyzed at Alpha Labs in Ukiah, California.

Nutrient sampling was conducted for total organic nitrogen, ammonia, unionized ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total nitrogen, and total phosphorus, as well as for *chlorophyll a*, which is a measurable parameter of algal growth that can be tied to excessive nutrient concentrations and reflect a biostimulatory response. Grab samples were collected for presence of indicator bacteria including total coliforms, *Escherichia coli* (*E. coli*) and *Enterococcus*. These bacteria are considered indicators of water quality conditions that may be a concern for water contact recreation and public health. The results of sampling conducted for total orthophosphate, dissolved organic carbon, total organic carbon, total dissolved solids, and turbidity are included as an appendix; however, an analysis and discussion of these constituents is not included in this report. Temperature and pH were recorded during grab sampling events and are included in Appendix A-6.

Results

Water quality conditions in 2012 were similar to trends observed in sampling from 2004 to 2011. The lower and middle reaches are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater layer. The upper reach is a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates up and downstream and appears to be affected in part by freshwater inflow rates, tidal inundation, barrier beach closure, and subsequent tidal cycles following reopening of the barrier beach. The river upstream of Duncans Mills is considered predominantly freshwater habitat. The lower and middle reaches of the Estuary are subject to tidally-influenced fluctuations in water depth during open conditions and inundation during barrier beach closure, as is the upper reach and the maximum backwater area to a lesser degree.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen (DO), pH, and salinity recorded at the various datasonde monitoring stations. Data associated with malfunctioning datasonde equipment has been removed from the data sets, resulting in the data gaps. These data gaps may affect minimum, mean, and maximum values of the various monitored constituents, including at the Patty's Rock surface sonde in July, the Heron Rookery bottom sonde in July, and the Monte Rio sonde in May. The Brown's Pool sonde was not operational during the monitoring period and no data were collected.

Although gaps exist in the 2012 data that affect sample statistics, Water Agency staff has collected long time-series data on an hourly frequency for several years at most of these stations, and it is unlikely that the missing data appreciably affected the broader understanding of water quality conditions within the estuary. The following sections provide a brief discussion of the results observed for each parameter monitored.

Salinity

Full strength seawater has a salinity of approximately 35 ppt, with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994). All of the mid-depth sondes in the lower and middle reaches were located in a predominantly saline environment, whereas the surface sondes were located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The Willow Creek sonde was located just upstream of the confluence with the Russian River, where predominantly freshwater conditions observed in the creek during higher springtime flows transitioned to a brackish environment during lower dry season flows.

Table 4.1.1. Russian River Estuary 2012 water quality monitoring results. Minimum, mean, and maximum temperature (degrees Celsius), depth (meters), dissolved oxygen (percent) saturation, dissolved oxygen (milligrams per Liter), hydrogen ion (pH), and salinity (parts per thousand).

Monitoring Station	Temperature	Depth	Dissolved Oxygen	Dissolved Oxygen	Hydrogen Ion	Salinity
Sonde	(°C)	(m)	(%) saturation	(mg/L)	(pH)	(ppt)
Mouth						
Surface						
May 18 - November 19						
Min	8.9	0.7	55.4	5.0	7.7	0.3
Mean	15.9	0.9	115.3	10.2	8.3	17.7
Max	**25.5**	**1.6**	**261.5**	**21.1**	**9.1**	**34.1**
Mid-Depth						
May 18 - November 19						
Min	8.3	2.7	8.1	0.7	7.1	14.0
Mean	12.8	3.1	100.7	8.8	7.9	29.9
Max	**19.2**	**3.4**	**267.9**	**22.7**	**8.9**	**34.2**
Patty's Rock						
Surface						
May 15 - November 19						
Min	10.7	0.6	57.4	4.8	7.6	0.2
Mean	16.8	0.9	115.4	10.1	8.2	16.6
Max	**25.8**	**1.3**	**289.7**	**25.6**	**8.8**	**32.4**
Mid-Depth						
May 15 - November 19						
Min	9.6	2.6	19.5	1.6	7.2	17.6
Mean	14.5	3.1	105.3	8.9	7.9	29.8
Max	**23.0**	**3.2**	**192.9**	**16.7**	**8.4**	**33.5**
Willow Creek						
Mid-Depth						
May 2 - December 31						
Min	5.3	0.4	0.0	0.0	6.5	0.0
Mean	16.1	0.9	83.5	7.9	7.5	10.5
Max	**23.4**	**3.0**	**214.5**	**18.8**	**9.1**	**28.3**
Sheephouse Creek						
Mid-Depth						
May 15 - October 30						
Min	13.4	3.3	44.6	3.6	7.1	0.2
Mean	17.9	3.5	135.1	10.8	7.9	27.5
Max	**25.0**	**3.8**	**290.1**	**21.4**	**8.5**	**31.7**

(continues on next page)

Table 4.1.1 (cont.). Russian River Estuary 2012 water quality monitoring results. Minimum, mean, and maximum temperature (degrees Celsius), depth (meters), dissolved oxygen (percent) saturation, dissolved oxygen (milligrams per Liter), hydrogen ion (pH), and salinity (parts per thousand).

Monitoring Station *Sonde*	Temperature (°C)	Depth (m)	Dissolved Oxygen (%) saturation	Dissolved Oxygen (mg/L)	Hydrogen Ion (pH)	Salinity (ppt)
Heron Rookery						
Mid-Depth						
May 16 - October 23						
Min	16.9	4.3	0.0	0.0	6.7	0.1
Mean	21.5	4.6	64.5	5.5	7.7	14.9
Max	**27.4**	**4.9**	**159.2**	**13.6**	**8.9**	**28.0**
Bottom						
May 16 - October 23						
Min	16.2	6.7	0.0	0.0	6.2	0.2
Mean	20.0	8.8	10.3	0.9	6.9	21.7
Max	**24.1**	**9.4**	**119.2**	**10.7**	**8.5**	**28.0**
Freezeout Creek						
Bottom						
August 6 - November 19						
Min	11.5	5.4	0.0	0.0	5.8	0.1
Mean	19.0	6.2	82.1	7.5	6.9	4.6
Max	**22.8**	**6.7**	**294.4**	**26.3**	**8.4**	**10.1**
Austin Creek						
Mid-Depth						
April 18 - November 27						
Min	10.7	0.2	0.0	0.0	7.2	0.1
Mean	15.9	0.5	65.6	6.5	7.7	0.2
Max	**20.7**	**2.1**	**108.9**	**11.1**	**8.4**	**0.2**
Villa Grande						
Bottom						
May 4 - November 27						
Min	10.6	6.0	30.1	2.6	7.1	0.1
Mean	19.5	7.1	86.6	8.0	7.7	0.1
Max	**24.4**	**8.2**	**131.9**	**12.0**	**8.5**	**0.1**
Monte Rio						
Mid-Depth						
May 4 - October 29						
Min	14.5	0.4	78.7	7.1	7.5	0.1
Mean	21.0	0.7	99.2	8.8	7.8	0.1
Max	**26.2**	**1.1**	**124.8**	**10.4**	**8.4**	**0.2**

In the upper reach, the Estuary typically transitions from predominantly saline conditions to brackish and freshwater conditions in the Heron Rookery area. Upstream, the Freezeout Creek station is located in a predominantly freshwater environment; however, saltwater can occur in the lower half of the water column during open estuary conditions with lower in-stream flows, as well as during barrier beach closure or perched conditions. The Brown's Pool station is located in predominantly freshwater habitat in the upper reach of the Estuary, just downstream of the confluence with Austin Creek and the beginning of the maximum backwater area.

The Austin Creek, Villa Grande, and Monte Rio stations are located in the maximum backwater area in freshwater habitat that can become backwatered during high tides, barrier beach closures/lagoon formation and perched mouth conditions.

Lower and Middle Reaches

The surface sondes at the Mouth and Patty's Rock stations were suspended at a depth of approximately 1 meter, and experienced frequent hourly fluctuations in salinity during open conditions. These fluctuations are influenced by freshwater inflows, tidal movement, and expansion and contraction of the salt wedge. The freshwater layer was persistent at the surface sondes during spring peak flows and perched river mouth conditions. Muted tides and perched conditions occurred during partial barrier beach formation when the river mouth was adjacent to the jetty. Salinity concentrations ranged from 0.3 to 34.1 ppt at the Mouth surface sonde and 0.2 to 32.4 ppt at the Patty's Rock surface sonde (Table 4.1.1).

The mid-depth sondes at the Mouth, Patty's Rock, and Sheephouse Creek stations were suspended at a depth of approximately 3 meters below the surface, and also experienced frequent fluctuations in salinity during open conditions, though to a lesser degree than their respective surface sondes. Concentrations ranged from 14.0 to 34.2 ppt at the Mouth, 17.6 to 33.5 ppt at Patty's Rock, and 0.2 to 31.7 ppt at Sheephouse Creek (Table 4.1.1). Minimum concentrations in the lower estuary at the Mouth and Patty's Rock mid-depth sondes were observed during perched conditions, whereas minimum conditions at the Sheephouse Creek mid-depth sonde were observed during elevated springtime flows in mid-May (Figures 4.1.3 through 4.1.5).

Salinity concentrations periodically decreased during muted tidal cycles and perched conditions in June and July and again in October and November (Figures 4.1.3 through 4.1.5). The orientation of the jetty groin may have also acted as a barrier to tidal exchange and salinity intrusion resulting in partial lagoon formation (Photos 4.1.1 and 4.1.2).

Declines in salinity during perched conditions and partial lagoon formation were due to a combination of freshwater inflows increasing the depth of the freshwater layer over the salt layer, a reduction in tidal inflow, the compression and leveling out of the salt layer, and, potentially, seepage of saline water through the barrier beach. Salinity returned to pre-perched levels after the mouth naturally reopened, although the time required to return to pre-perched conditions varied at each site and differed between perched events. This variability was related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

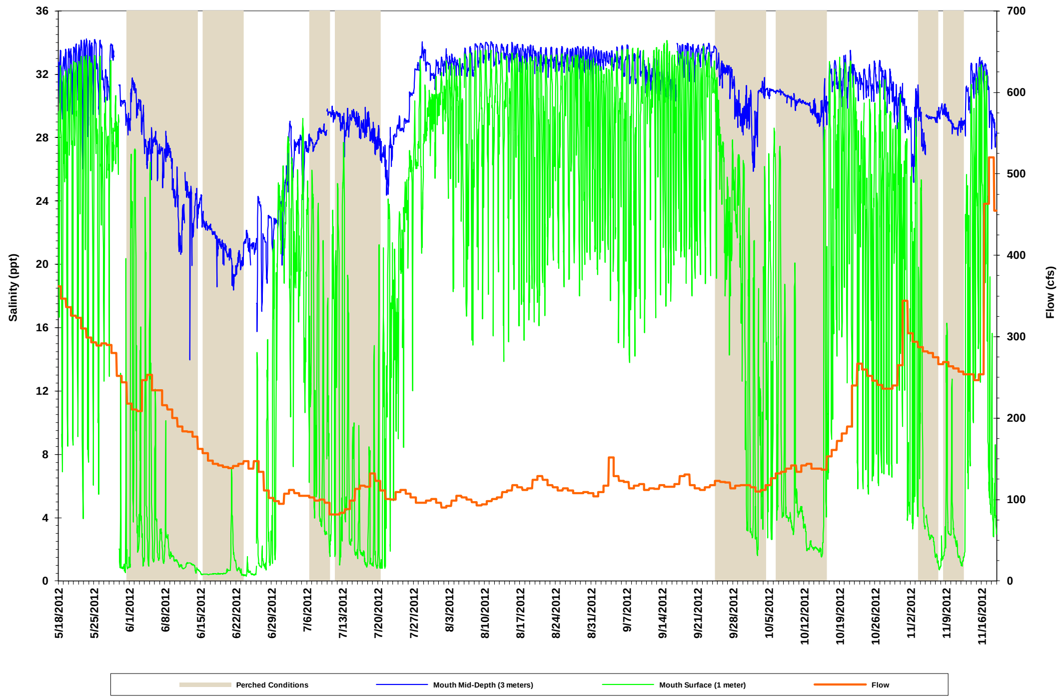

Figure 4.1.3. 2012 Russian River Mouth Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

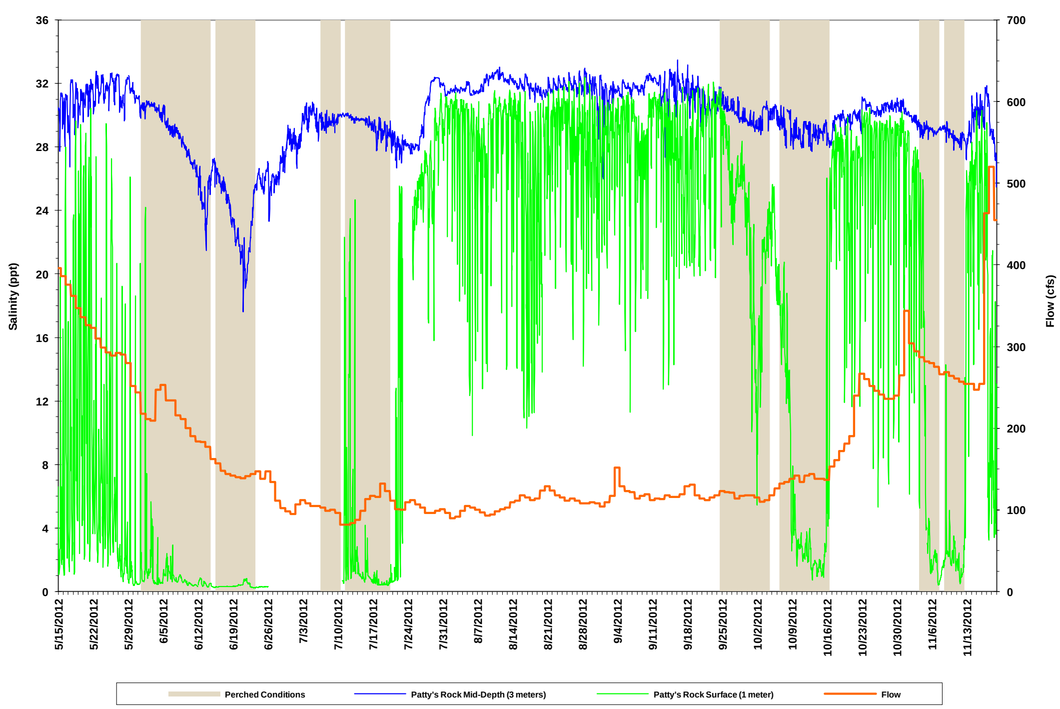

Figure 4.1.4. 2012 Russian River at Patty's Rock Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

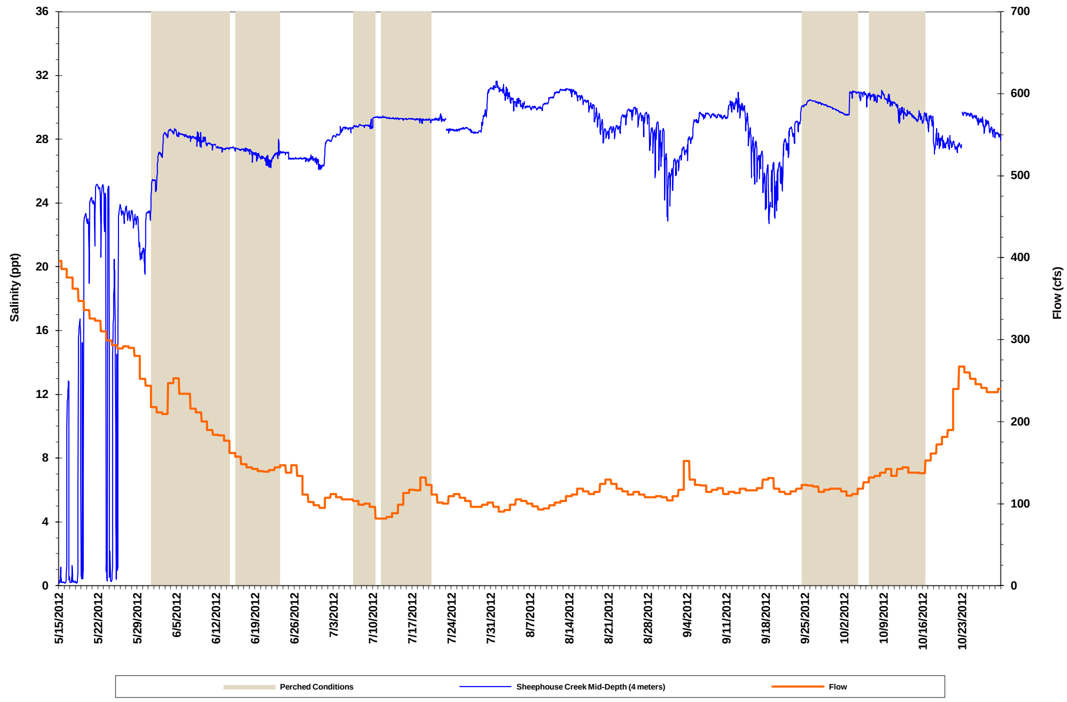

Figure 4.1.5. 2012 Russian River at Sheephouse Creek Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Photo 4.1.1. Russian River Mouth and Jetty from Jenner Overlook – May 31, 2012

Photo 4.1. 2. Russian River Mouth and Jetty from Jenner Overlook – June 20, 2012.

During the first half of the monitoring period, the Willow Creek Station was predominantly freshwater habitat that experienced brief spikes in salinity as spring flows receded in May (Figure 4.1.6). Salinity concentrations increased during perched conditions in June and declined when the barrier beach reopened, but did not increase during the second set of perched conditions in mid-July. However, salinity was detected during open conditions in early August and remained until late November when flows in the river increased above 500 cfs. Salinity concentrations varied over the season with changing creek and mainstem river flows, tidal cycles, and perched mouth conditions, but remained primarily brackish (Table 4.1.1).

Upper Reach

The Heron Rookery and Freezeout Creek stations included a bottom sonde and the Heron Rookery Station also had a mid-depth sonde. The Heron Rookery station is located in a deep pool approximately 7.5 km upstream from the river mouth in an area where the Estuary begins to transition from predominantly saline conditions to brackish and freshwater conditions. The bottom and mid-depth sondes at Heron Rookery had mean salinity concentrations of 21.7 ppt and 14.9 ppt, respectively (Table 4.1.1). Salinity levels were observed to range from 0.2 to 28.0 ppt at the bottom sonde, and 0.1 to 28.0 ppt at the mid-depth sonde (Figure 4.1.7).

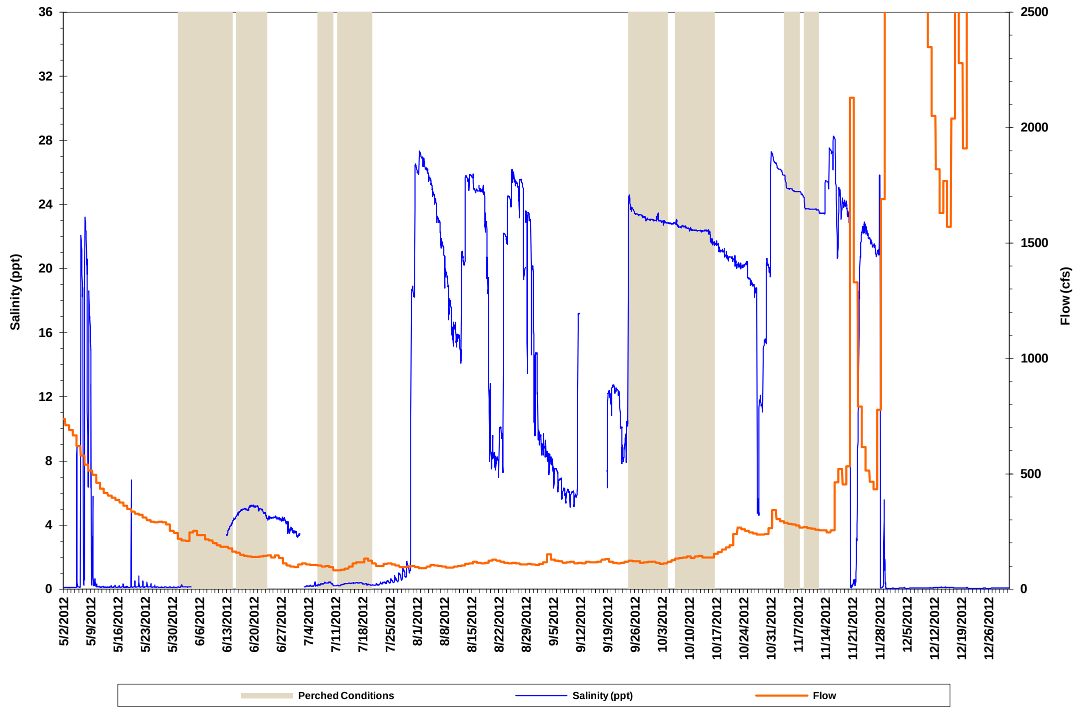

Figure 4.1.6. **2012 Willow Creek Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.**

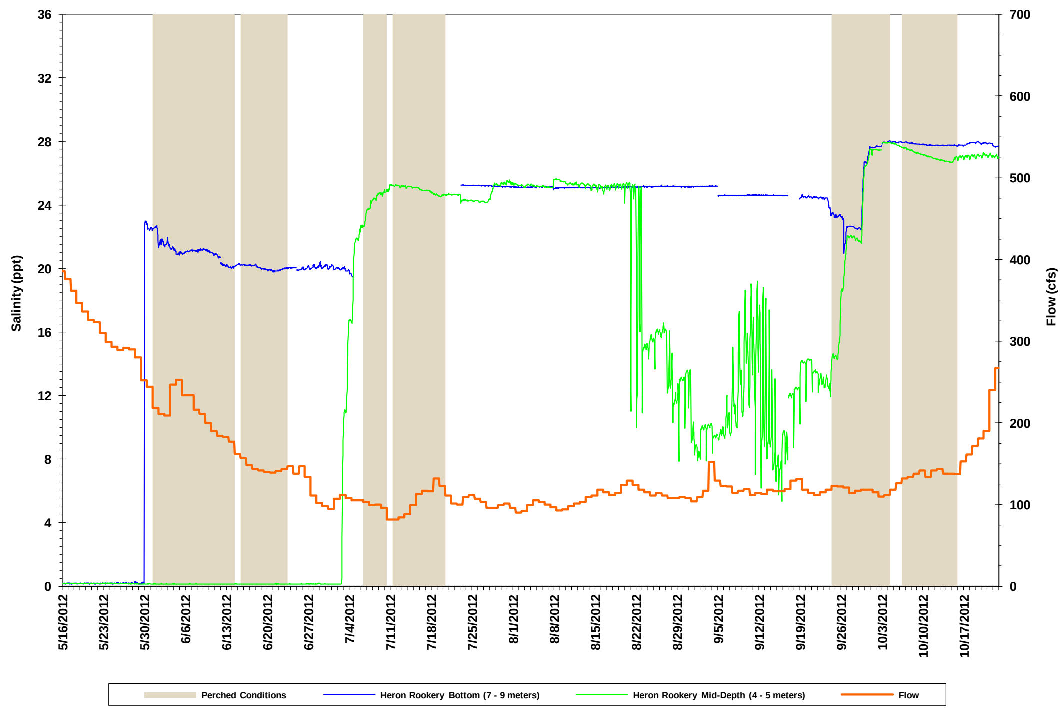

Figure 4.1.7. 2012 Russian River at Heron Rookery Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

The Freezeout Creek Station is located approximately 9.5 km upstream from the river mouth in a pool approximately 300 meters downstream of the confluence of Freezeout Creek. This station was located in a predominantly freshwater habitat, but was occasionally subject to elevated salinity levels as the salt wedge migrated upstream during both open and perched conditions (Figure 4.1.8). The bottom sonde at Freezeout Creek had a mean salinity concentration of 4.6 ppt and levels that ranged from 0.1 to 10.1 ppt (Table 4.1.1).

Salinity was observed to increase at the Heron Rookery bottom sonde during muted tides continuing through the first perched event in June as the salt layer stratified and flattened out underneath the developing freshwater layer. Mainstem Russian River flows were approximately 300 cfs and decreasing (Figure 4.1.7). In early July, salinity concentrations again increased during muted tides at the bottom and mid-depth sondes to approximately 25 ppt. Salinity remained elevated at the bottom of the Heron Rookery Station through the rest of the monitoring season. However, salinity concentrations decreased and fluctuated at mid-depth during open conditions in August and September before increasing during perched conditions in late September.

The Freezeout Creek station was not installed until early August due to equipment issues, so the transition from freshwater to brackish that typically occurs in late spring was not recorded. Maximum salinity concentrations at the bottom of Freezeout Creek remained below 8 ppt during the monitoring season under both open and closed conditions. However, concentrations were observed to increase to approximately 10 ppt during perched conditions in November (Figure 4.1.8). Salinity was also observed to decline during open conditions with daily maximums of less than 2ppt (<2ppt) and often returned to freshwater levels on a daily basis (Figure 4.1.8). The Freezeout Creek station transitioned back to freshwater habitat when flows increased to approximately 500 cfs in November.

Maximum Backwater Area

The three stations located in the maximum backwater area included one tributary station in lower Austin Creek and the Villa Grande and Monte Rio stations in the mainstem Russian River (Figure 4.1.1). None of the stations in the maximum backwater area were observed to have salinity levels above normal background conditions expected in freshwater habitat, during both open and perched conditions (Figures 4.1.9 through 4.1.11). All three stations had maximum salinity concentrations of 0.2 ppt, with mean concentrations ranging from 0.1 to 0.2 ppt (Table 4.1.1).

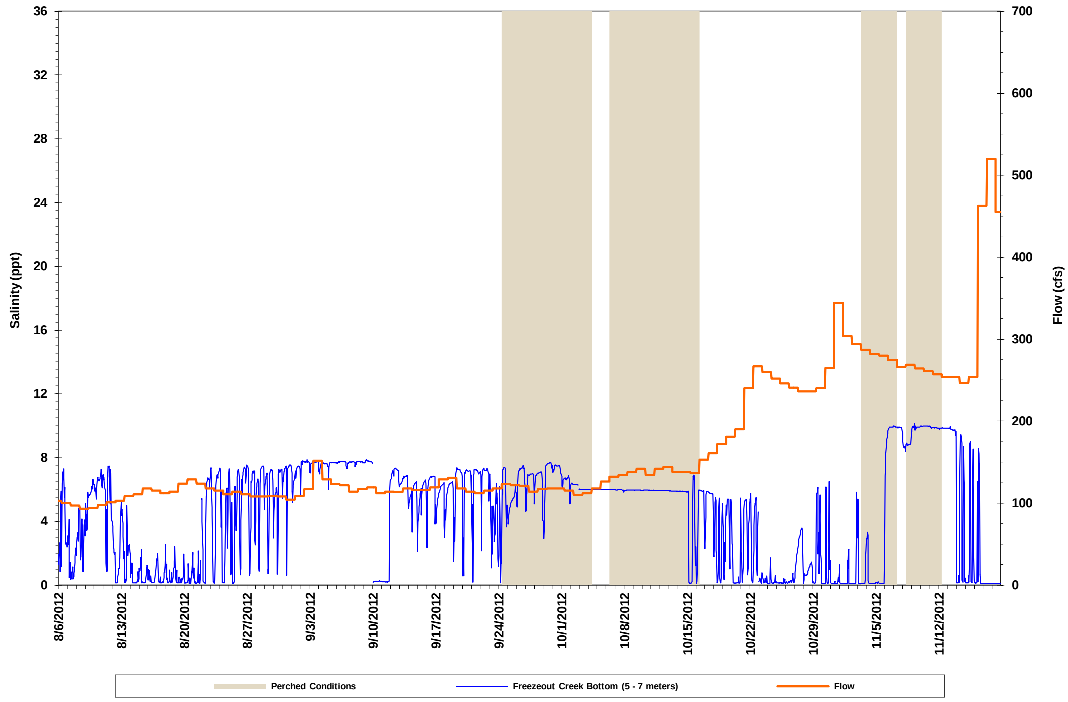

Figure 4.1.8. 2012 Russian River at Freezeout Creek Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

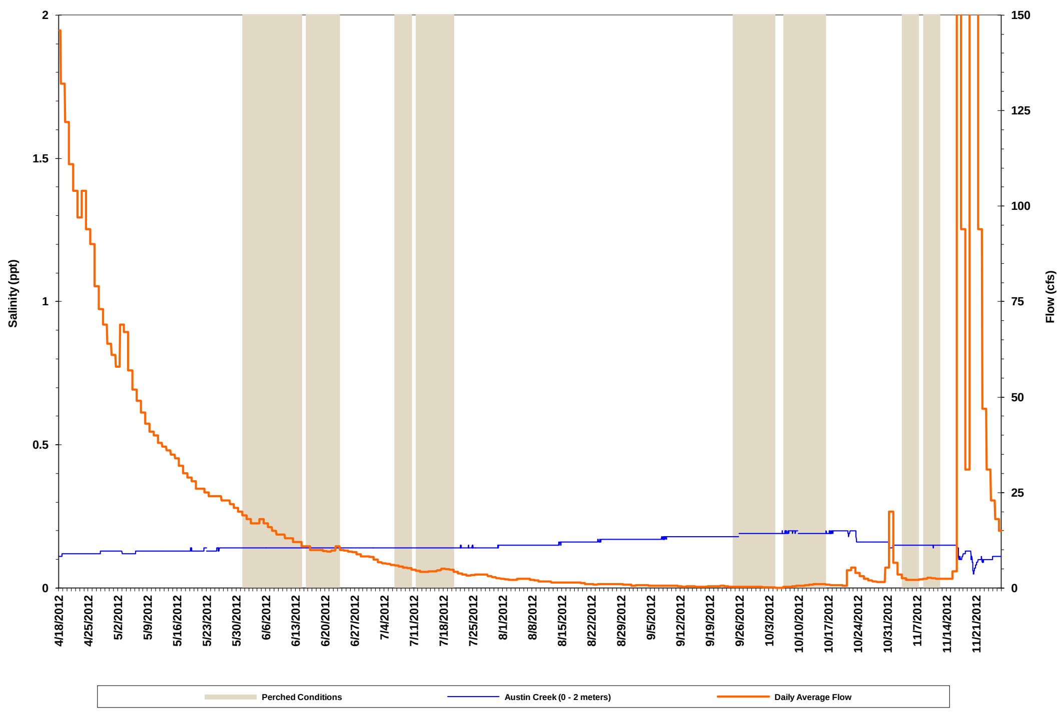

Figure 4.1. 9. 2012 Austin Creek Salinity Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

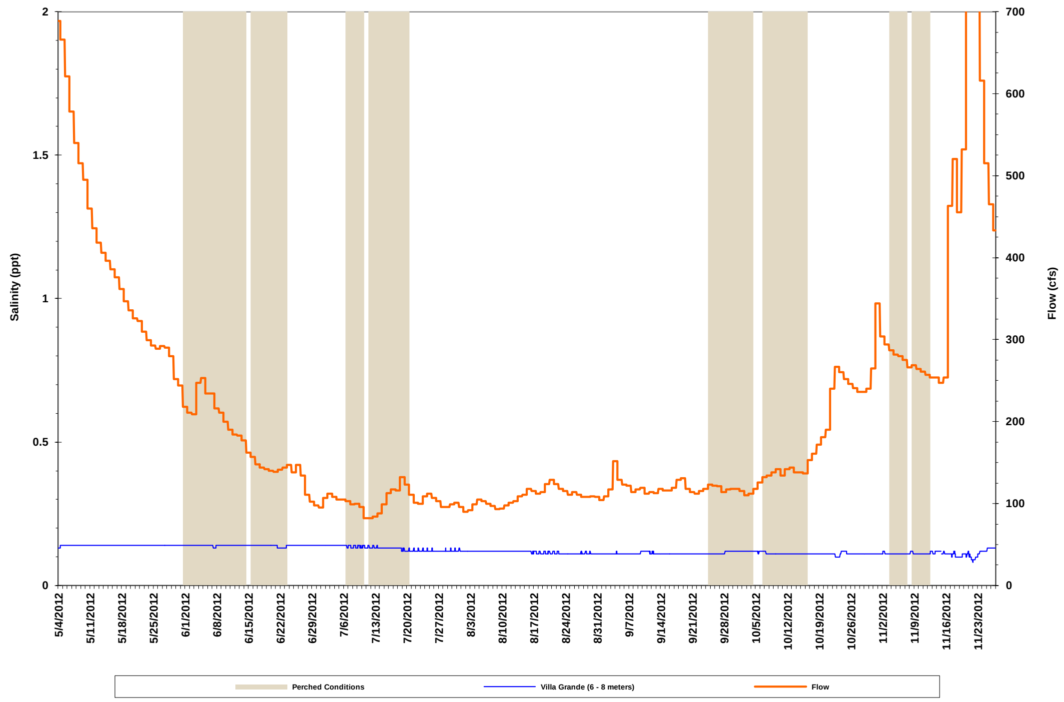

Figure 4.1.10. 2012 Russian River at Villa Grande Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

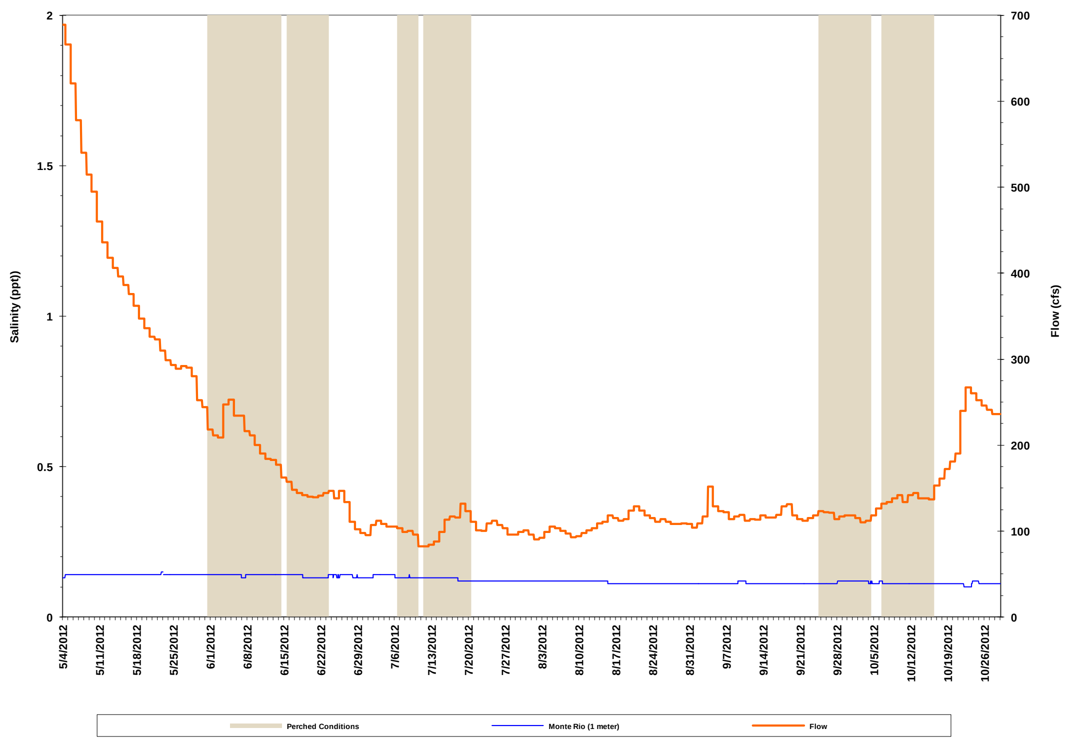

Figure 4.1.11. 2012 Russian River at Monte Rio Station salinity in parts per thousand (ppt). Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Temperature

During open estuary conditions, mainstem water temperatures were reflective of the halocline, with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures in freshwater at the mid-depth and surface sondes (Figures 4.1.12 through 4.1.17). The differences in temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of water. During open estuary conditions, saltwater from the Pacific Ocean, where temperatures are typically around 10 degrees Celsius (degrees C), enters the Estuary. Whereas, the mainstem Russian River, with water temperatures reaching as high as 26 degrees C in the interior valleys, is the primary source of freshwater into the Estuary.

Increasing temperatures associated with fresh/saltwater stratification were observed during perched mouth conditions (Figures 4.1.12 through 4.1.14 and 4.1.16). Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. When the estuary is closed, or the river mouth is perched and tidal inflow is reduced, solar radiation can heat the underlying saline layer. The overlying freshwater surface layer restricts the release of this heat, which can result in higher water temperatures in the underlying saline layer than in the overlying freshwater layer. Stratification-based heating has also been observed to result in higher temperatures in the mid-depth saline layer compared to the bottom layer in deep pools, forming a three layered system. This stratification based heating can also contribute to higher seasonal mean temperatures in the saline layer than would be expected to occur under open conditions.

Lower and Middle Reaches

The surface sondes were located at the freshwater/saltwater interface and were observed to have maximum temperatures of 25.5 and 25.8 degrees C at the Mouth and Patty's Rock, respectively. Whereas, the mid-depth sondes were located primarily in saltwater and had maximum temperatures of 19.2, 23.0, and 25.0 degrees C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had mean temperatures of 15.9 and 16.8 degrees C and minimum temperatures of 8.9 and 10.7 degrees C at the Mouth and Patty's Rock, respectively (Table 4.1.1). The mid-depth sondes had mean temperatures of 12.8, 14.5, and 17.9 degrees C, and minimum temperatures of 8.3, 9.6, and 13.4 degrees C at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1).

During the first half of the monitoring period, the Willow Creek station was located in predominantly freshwater habitat that experienced brief spikes in salinity as spring flows receded in May (Figure 4.1.6). Salinity concentrations increased when saline water migrated to the station during perched conditions in June and receded when the barrier beach reopened, but did not increase during the second set of perched conditions in mid-July. However, saline water was observed to migrate to this location during open conditions in early August and remain until late November when flows increased above

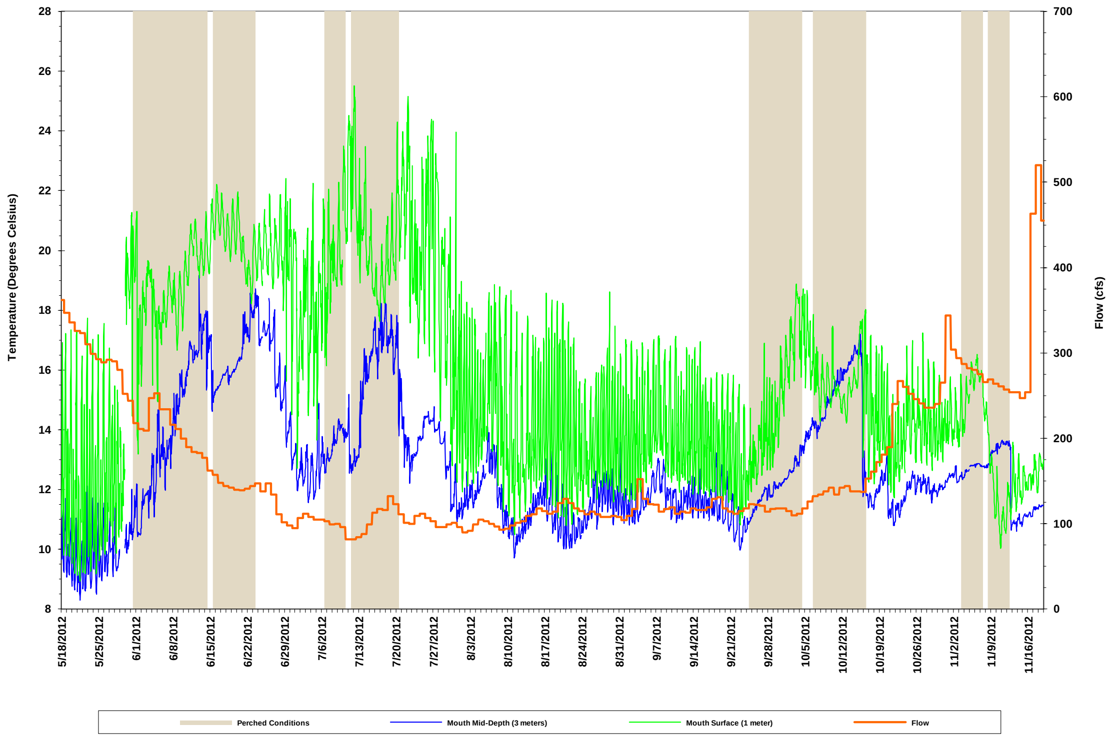

Figure 4.1.12. 2012 Russian River Mouth Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

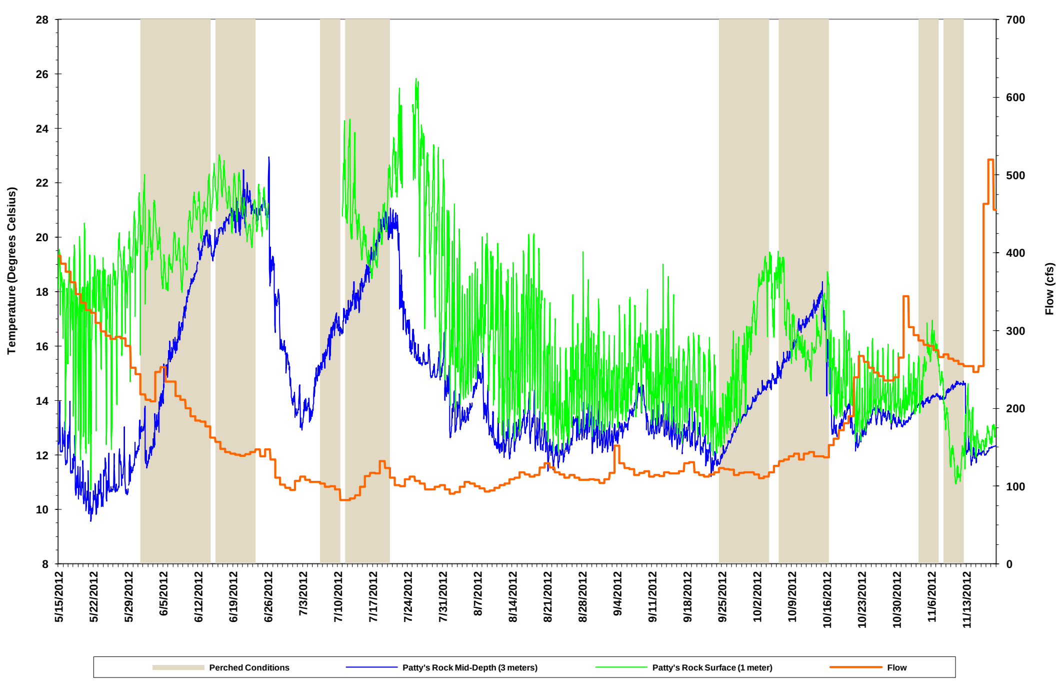

Figure 4.1.13. 2012 Russian River at Patty's Rock Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

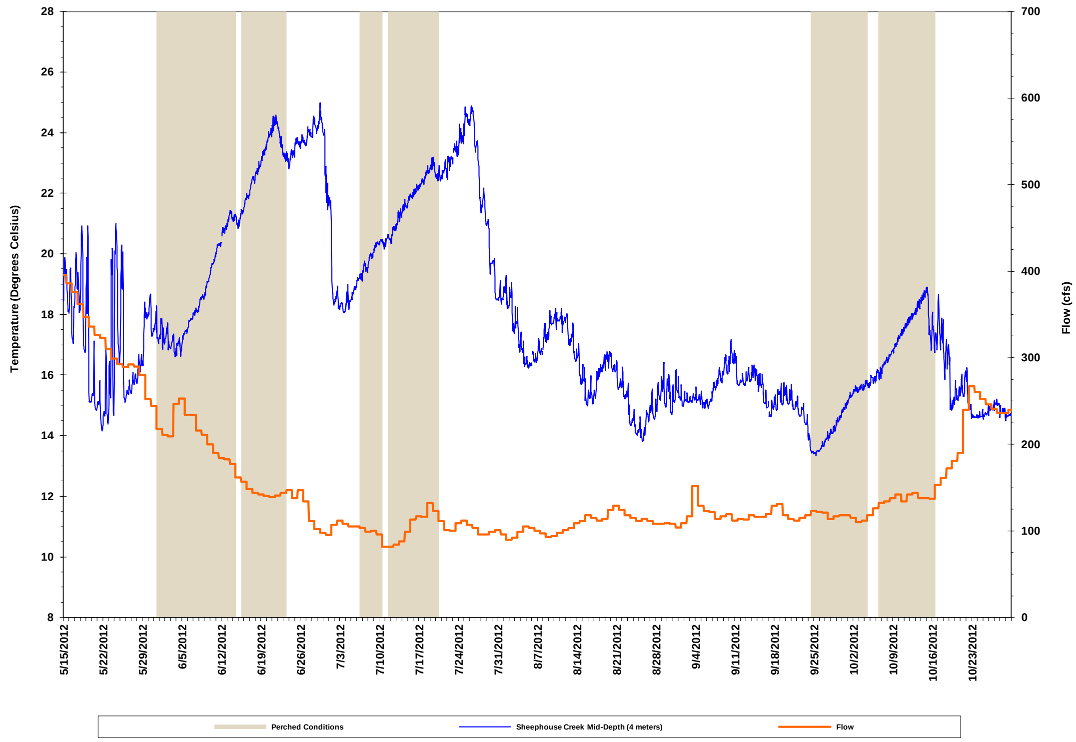

Figure 4.1.14. 2012 Russian River at Sheephouse Creek Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

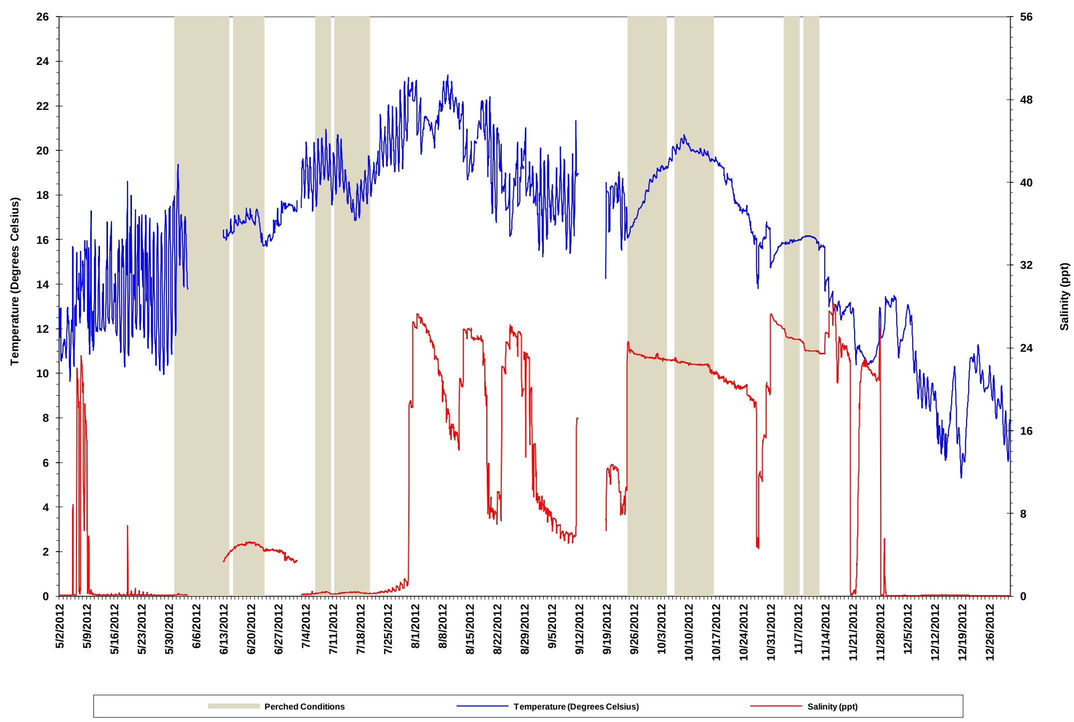

Figure 4.1.15. 2012 Willow Creek Station water temperature and salinity in parts per thousand (ppt).

500 cfs. At this point, the station transitioned to a brackish system, with salinity levels fluctuating throughout the season associated with the tidal cycle. Although temperatures were observed to increase, on average, through the summer season, temperatures were also observed to temporarily decrease when a given tidal cycle pushed a fresh source of cool saline water to the station (Figure 4.1.15). The Willow Creek Station had a maximum temperature of 23.4 degrees C, which occurred in brackish water during open conditions in August. The mean temperature at the site was 16.1 degrees C, and the minimum temperature recorded was 5.3 degrees C (Table 4.1.1). Overall minimum temperatures were observed in freshwater conditions in December. Minimum temperatures observed within the monitoring period occurred during periods of cooler weather in May and October. Temperature response to perched conditions was variable and dependent on the presence of freshwater or saline water as well as the relative temperature of the saline layer migrating into and out of the station from the mainstem.

Upper Reach

Overall estuarine temperatures in both the saline and freshwater layers were typically hottest at the upper reach stations, as recorded at Heron Rookery and Freezeout Creek, and became progressively cooler as the water flowed downstream, closer to the cooling effects of the coast and ocean.

The bottom sondes at Heron Rookery and Freezeout Creek had maximum temperatures of 24.1 and 22.8 degrees C, minimum temperatures of 16.2 and 11.5 degrees C, and mean temperatures of 20.0 and 19.0 degrees C, respectively (Table 4.1.1). The mid-depth sonde at Heron Rookery had a maximum temperature of 27.4 degrees C, a minimum temperature of 16.9 degrees C, and a mean temperature of 21.5 degrees C, respectively (Table 4.1.1). The lower minimum temperature at Freezeout Creek was due to sonde being in operation later than the Heron Rookery Station; water temperature was colder during open conditions in November (Figures 4.1.16 and 4.1.17).

The maximum temperatures at the Heron Rookery sondes occurred in brackish water during open conditions and following a period of perched conditions. This resulted in extensive solar heating of the resident salt water in the pool and the retention of that heat by the overlying freshwater layer. Stronger circulation patterns at the end of August resulted in a decline in salinity at mid-depth and a corresponding decline in temperatures (Figures 4.1.7 and 4.1.16). However, temperatures remained elevated at the bottom sonde, along with salinity concentrations, until cooler salt water migrated into the station during a perched event at the end of September.

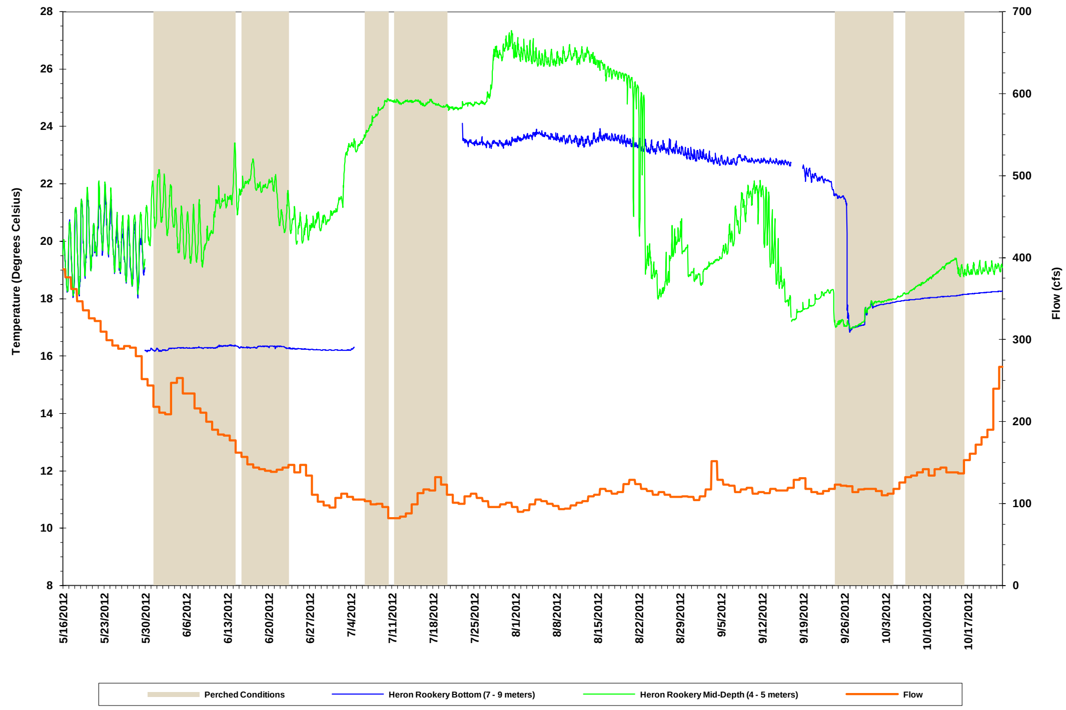

Figure 4.1.16. 2012 Russian River at Heron Rookery Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

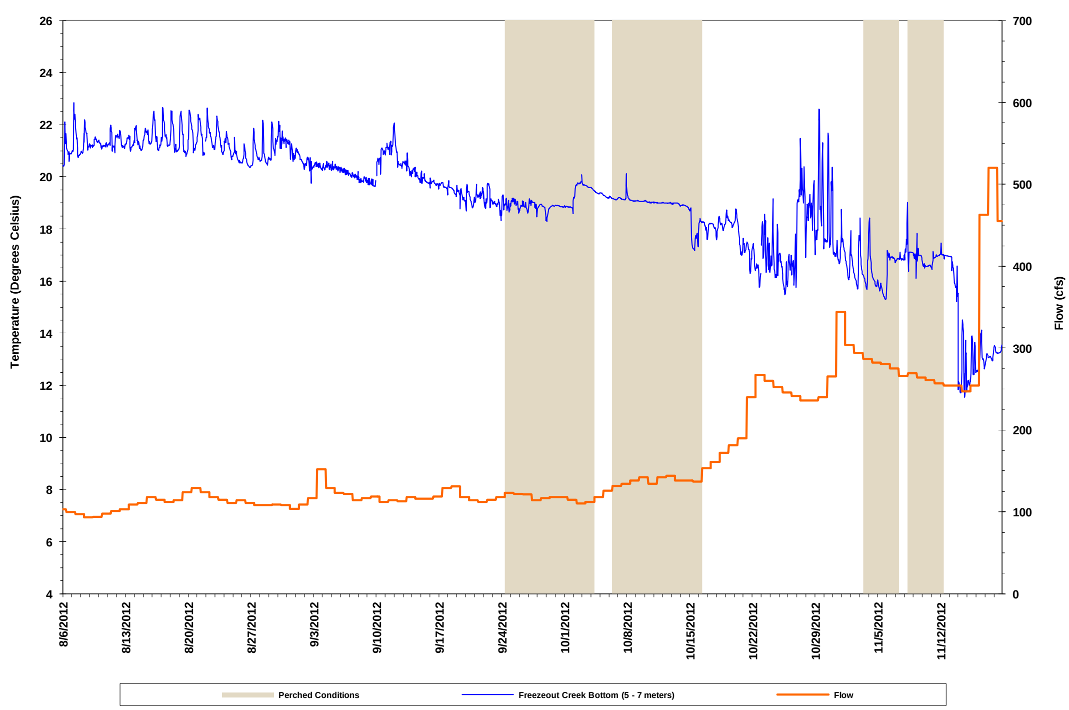

Figure 4.1.17. 2012 Russian River at Freezeout Creek Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Freezeout Creek remained primarily brackish from August through November, before transitioning back to freshwater conditions when flows increased to approximately 500 cfs (Figure 4.1.8). Salinity was also observed to decrease to freshwater levels on a daily basis during open conditions in August and October (Figure 4.1.8). As a result, perched conditions were not observed to have a significant effect on water temperatures in 2012, with both minor increases and decreases being observed to occur (Figure 4.1.17).

Maximum Backwater Area

Austin Creek water temperatures ranged from 10.7 to 20.7 degrees C, Villa Grande ranged from 10.6 to 24.4 degrees C, and Monte Rio ranged from 14.5 to 26.2 degrees C (Table 4.1.1). Perched conditions were not observed to have a significant effect on water temperatures at the Austin Creek,Villa Grande, and Monte Rio stations. Slight increases in water temperature during the first perched river mouth event coincided with increases in air temperatures. Likewise, decreases in water temperature during the second perched event were associated with decreases in air temperatures (Figures 4.1.18 to 4.1.20).

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary, including the maximum backwater area, depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both consume and produce DO during photosynthesis and respiration. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel.[5] Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant, algal, and bacterial growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of a waterbody.

[5] *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

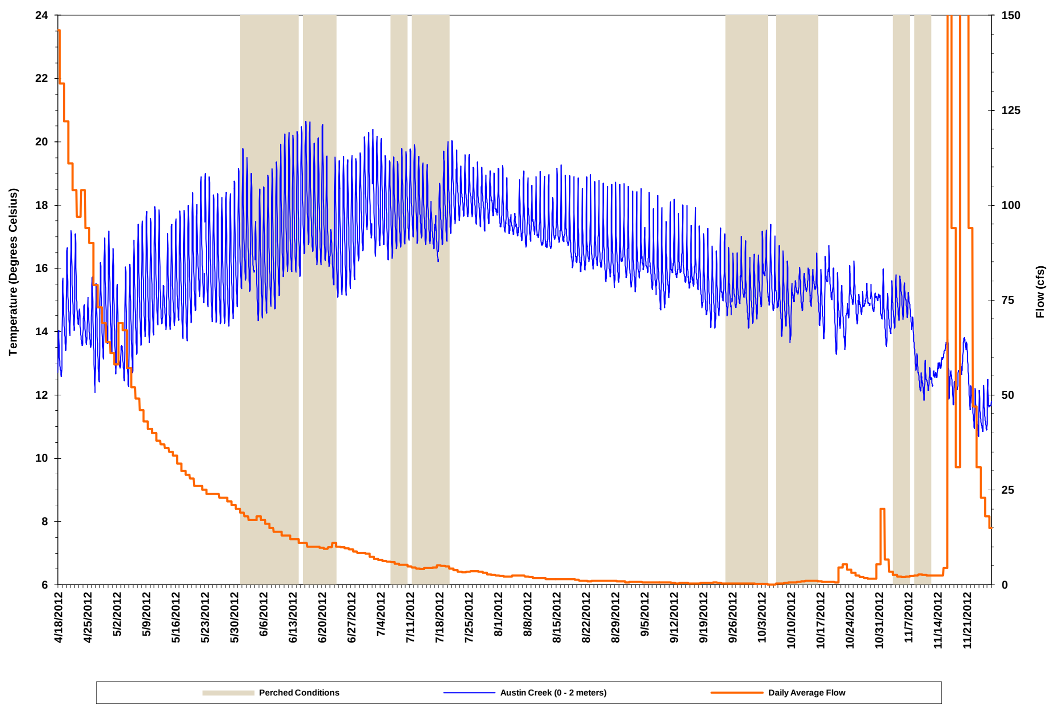

Figure 4.1.18. 2012 Austin Creek Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

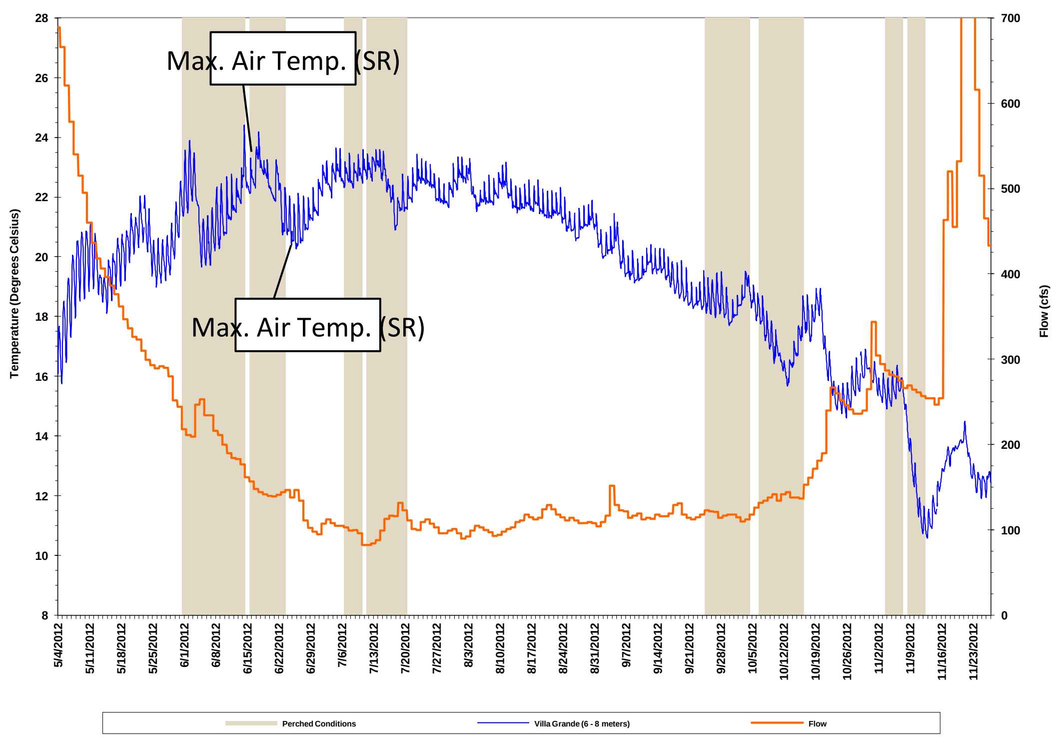

Figure 4.1.19. 2012 Russian River at Villa Grande Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

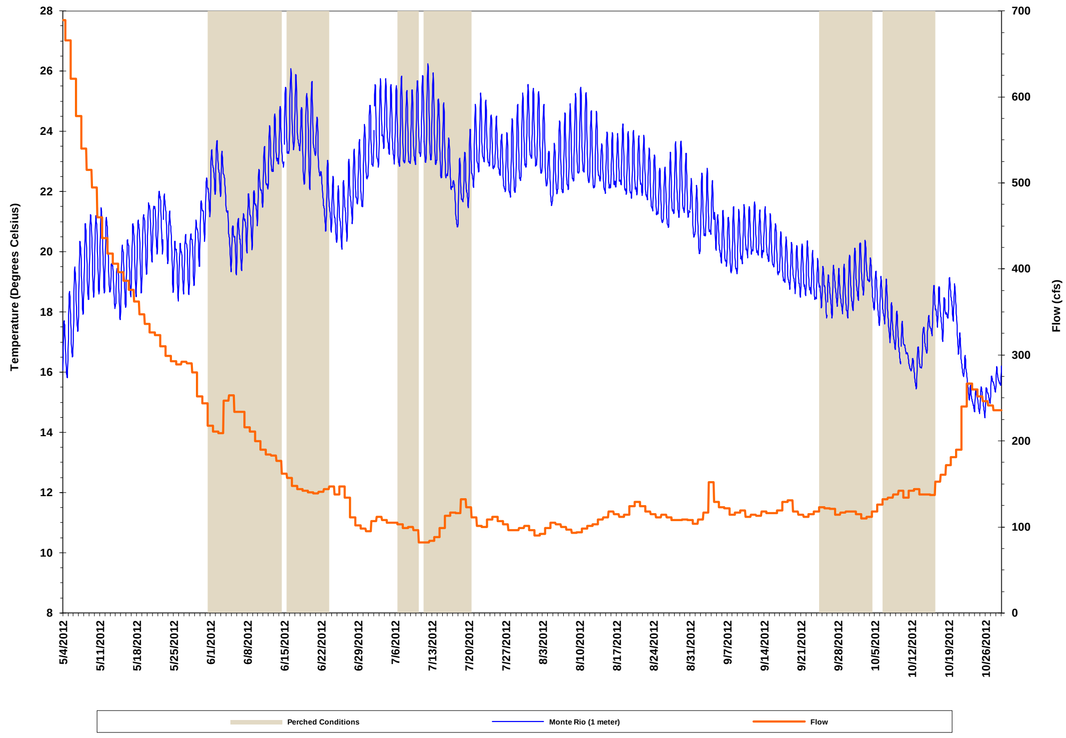

Figure 4.1.20. 2012 Russian River at Monte Rio Station water temperature. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Dissolved oxygen concentrations in the lower and middle reaches were generally higher at the surface sondes compared to the mid-depth sondes at a given sampling station (Table 4.1.1). More frequent supersaturation conditions at the surface sondes and periodic hypoxic conditions at the mid-depth sondes generally contributed to this difference. Supersaturation and hypoxic events were observed during open and perched conditions (Figures 4.1.21 through 4.1.23). Although the mid-depth sondes typically experienced less significant and less frequent supersaturation events than the corresponding surface sondes; mid-depth concentrations were observed to periodically exceed surface concentrations during both open and perched conditions (Figures 4.1.21 and 4.1.22).

Dissolved oxygen concentrations in Willow Creek were reflective of the presence of salinity, with higher mean values being observed in freshwater conditions and lower mean values being observed in saline water. DO concentrations remained relatively stable in freshwater, whereas concentrations became hypoxic to anoxic in the presence of saline water, most significantly during perched and open conditions in October and November (Figure 4.1.24).

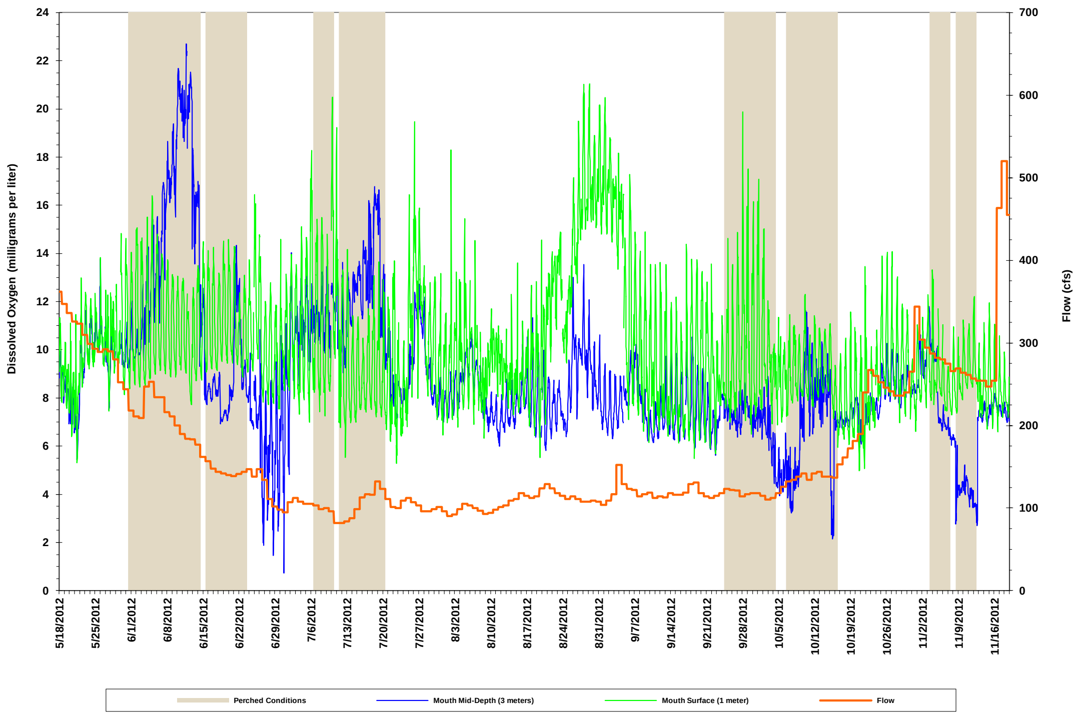

Figure 4.1.21. 2012 Russian River Mouth Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

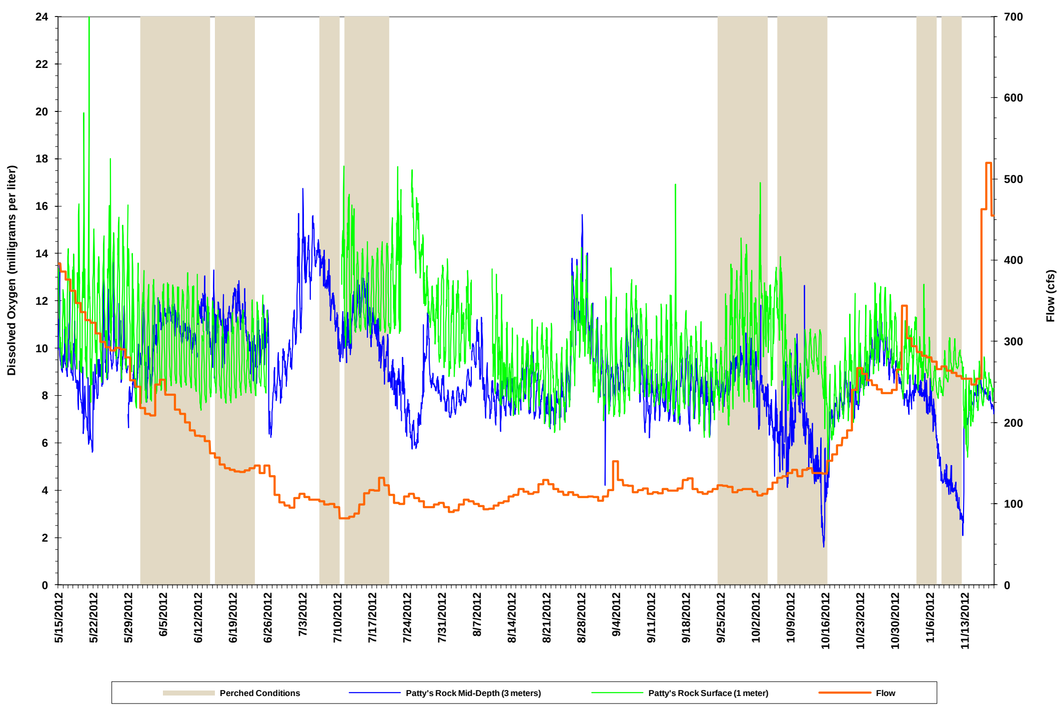

Figure 4.1.22. 2012 Russian River at Patty's Rock dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

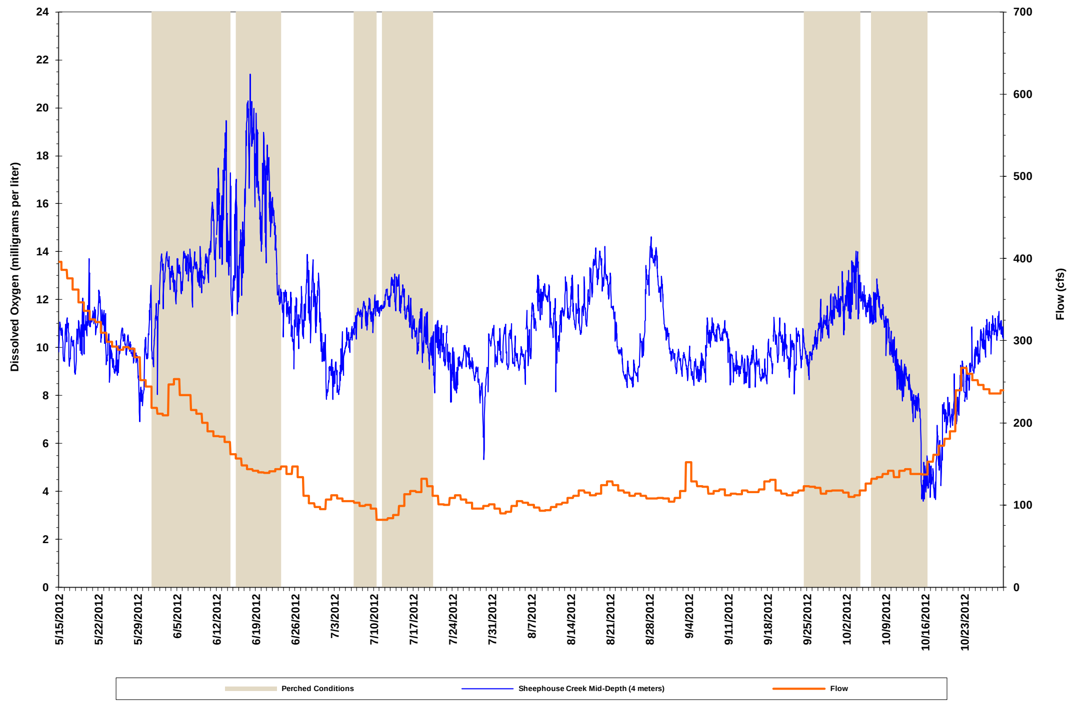

Figure 4.1.23. 2012 Russian River at Sheephouse Creek Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

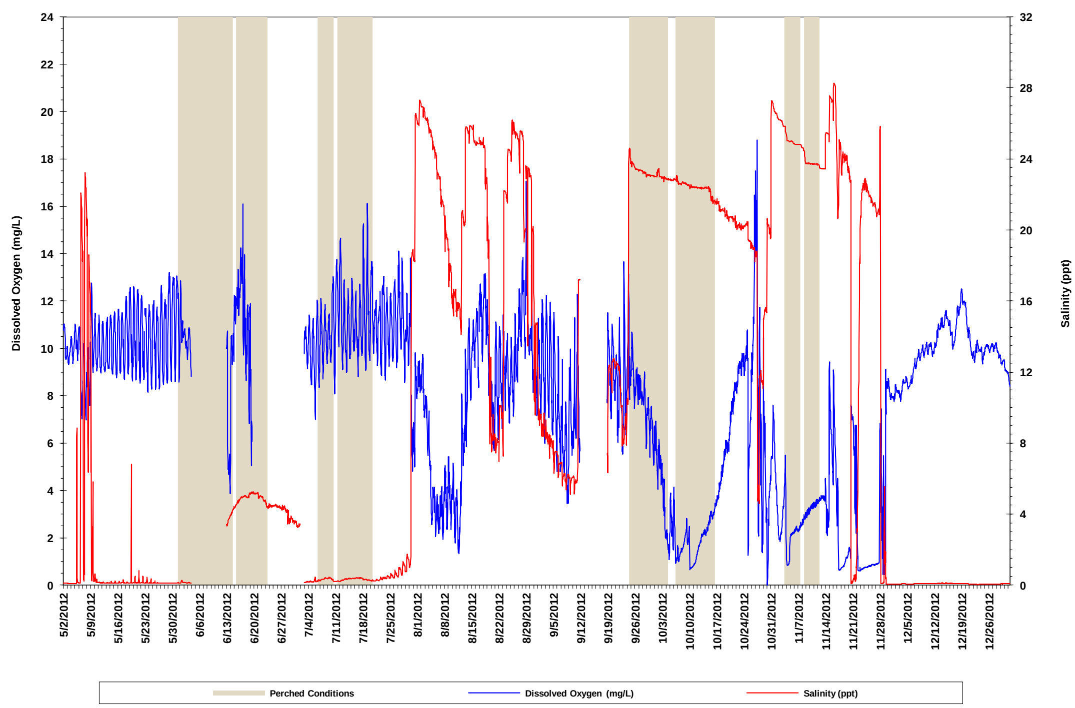

Figure 4.1.24. 2012 Willow Creek Station dissolved oxygen in milligrams per liter (mg/L) and salinity in parts per thousand (ppt).

Dissolved oxygen concentrations in the upper reach were also reflective of the presence of salinity, with lower minimum and mean concentrations in saline water and higher values in freshwater conditions. The Heron Rookery station transitioned from predominantly freshwater to saline conditions by early July and the Freezeout Creek station was predominantly brackish at the bottom from early August through the rest of the season (Figures 4.1.25 and 4.1.26). DO concentrations in the saline layer in the deeper water column were also observed to be lower in the upper reach of the Estuary during both open and perched conditions than DO concentrations in the lower and middle reaches. This effect was more pronounced at the bottom sondes with prolonged periods of hypoxia and anoxia observed in the presence of salinity. This occurs as the saline layer becomes trapped at the bottom of deep holes where there is less circulation, especially further upstream in the Estuary where the influence of the tides is reduced.

Lower and Middle Reaches

The stations in the lower and middle reaches experienced significant fluctuations in DO concentrations during open and perched Estuary conditions, with supersaturation and/or hypoxic conditions being observed (Figures 4.1.21 through 4.1.23). The surface sondes generally had higher DO concentrations than the mid-depth sondes (Table 4.1.1). The effect of perched conditions at the surface sondes was variable as DO concentrations remained unaffected, slightly declined, or increased in some instances. The Mouth and Patty's Rock surface sondes had minimum DO concentrations of 5.0 and 4.8 mg/L during open conditions and following perched events (Figures 4.1.21 and 4.1.22).

Short-term hypoxic and/or anoxic events previously observed during open conditions at mid-depth sondes in 2009 were observed again in 2012 at the Mouth Station. DO concentrations at the mid-depth sondes also declined to hypoxic levels during and following perched conditions (Figures 4.1.21 and 4.1.22). Minimum concentrations were 0.7, 1.6, and 3.6 mg/L at the Mouth, Patty's Rock, and Sheephouse Creek, respectively (Table 4.1.1).

Interestingly, DO response was variable during early and mid-season perched events at all three mid-depth sondes (Figures 4.1.21 through 4.1.23). This variability was most likely associated with changes to circulation and/or stratification patterns in the saline layer at each given station, however algal blooms can contribute to the supersaturation conditions observed. Conversely, DO concentrations became hypoxic at these stations during perched events in mid-October and November, but recovered within a few days of the barrier beach reopening.

The lower and middle reach surface sondes, and mid-depth sondes to a lesser degree, experienced hourly fluctuating supersaturation events. At times when oxygen production exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne 1994). DO concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentrations that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures typically observed in the Estuary.

The most significant supersaturation events were observed during open estuary conditions at the surface sondes and during perched conditions at the mid-depth sondes (Figures 4.1.21 through 4.1.23). The Mouth Surface Sonde had a maximum DO concentration of 21.1 mg/L, which corresponded to 262% saturation. The maximum DO concentration at the Patty's Rock surface sonde was 25.6 mg/L, or 290% saturation (Table 4.1.1). Maximum DO concentrations at the mid-depth sondes were approximately 22.7 mg/L (268%) at the Mouth, 16.7 mg/L (193%) at Patty's Rock, and 21.4 mg/L (290%) at Sheephouse Creek.

The Willow Creek sonde had a mean DO concentration of 7.9 mg/L, a maximum concentration of 18.8 mg/L (215%), and a minimum concentration of 0.0 mg/L (Table 4.1.1). Minimum values were observed to occur in brackish to saline water, with more pronounced hypoxic to anoxic conditions observed during and between perched events (Figure 4.1.24).

Upper Reach

The mid-depth sonde at Heron Rookery had a mean DO concentration of 5.5 mg/L, a maximum concentration of 13.6 mg/L (159%), and a minimum concentration of 0.0 mg/L (Table 4.1.1). The bottom sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 0.9 and 7.5 mg/L, maximum concentrations of 10.7 and 26.3 mg/L (119% and 294%), and minimum concentrations of 0.0 and 0.0 mg/L, respectively (Table 4.1.1).

The Heron Rookery mid-depth sonde was in freshwater until early July and had DO concentrations consistent with the mid-depth sondes in the lower and middle reaches (Table 4.1.1). However, the Heron Rookery mid-depth sonde recorded periodic hypoxic and anoxic conditions once saline water migrated to the station (Figure 4.1.25). This occurred under open and perched conditions for the rest of the season. DO levels at the Heron Rookery bottom sonde became hypoxic and anoxic when the saline layer migrated to the station at the end of May and remained depressed until the end of the season (Figure 4.1.25).

DO concentrations at the Freezeout Creek bottom sonde fluctuated significantly and became hypoxic and anoxic during open and perched conditions when saline water was present (Figure 4.1.26). The Freezeout Creek station was observed to be primarily brackish during this period, with concentrations typically below 10 ppt. Salinity concentrations were observed to fluctuate frequently between brackish and freshwater conditions during open conditions, often on a daily basis. DO typically fluctuated with

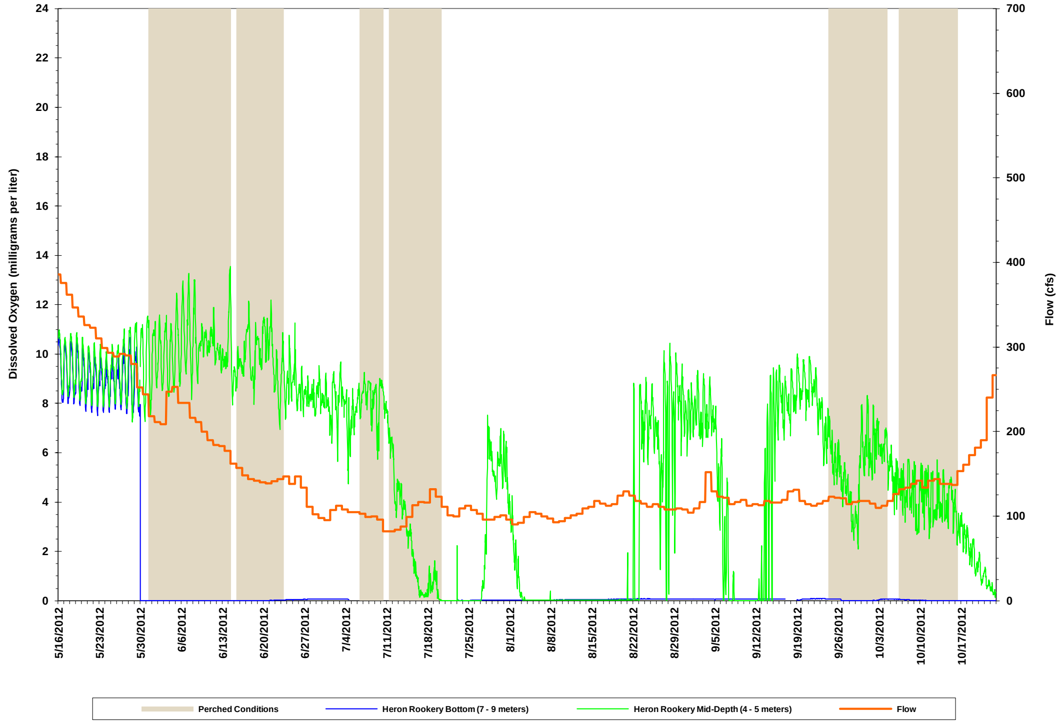

Figure 4.1.25. 2012 Russian River at Heron Rookery Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

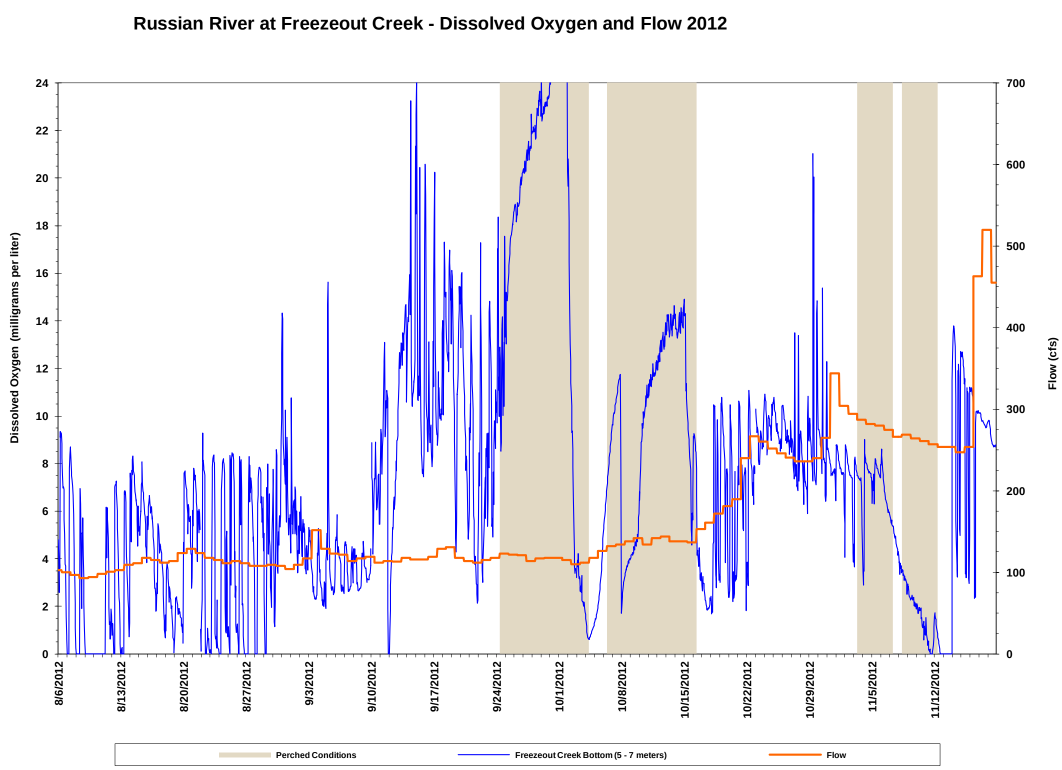

Figure 4.1. 26. 2012 Russian River at Freezeout Creek Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

changing salinity concentrations, becoming depressed in saline water and recovering in freshwater (Figure 4.1.26). Exceedingly high supersaturation values at Freezeout Creek appear to be the result of false positive readings that can be caused by hydrogen sulfide released during anoxic events. The DO probe utilizes a membrane that is permeable to hydrogen sulfide and can misinterpret high hydrogen sulfide concentrations as DO. Hydrogen sulfide odor and ferrous sulfide staining was often detected when retrieving and calibrating the Freezeout Creek sonde.

DO response to perched events was variable in the Upper Reach and dependent on salinity. The presence of salinity would typically coincide with depressed DO levels, but not always, suggesting that variability is dependent on relative DO concentrations in the migrating salt wedge, the length of time of perched conditions, the timing of subsequent perched events, freshwater inflow rates, and subsequent tidal inundation and mixing.

Maximum Backwater Area

The Austin Creek station had a mean DO concentration of 6.5 mg/L, a maximum concentration of 11.1 mg/L (109%), and a minimum concentration of 0.0 mg/L (Table 4.1.1). DO declined slightly through the season as flows declined, however concentrations remained relatively good for salmonids until flows became intermittent in August (measured at less than 2 cfs at the upstream USGS gauging station). At this point, the sonde was in an isolated pool and DO became hypoxic (Figure 4.1.27). Minimum values were observed in October during open conditions that followed a perched event (Figure 4.1.27). Freshwater inflow was intermittent at the time. DO concentrations remained depressed during a brief storm event in late October, and briefly recovered on the declining hydrograph, only to decrease to hypoxic levels once flows declined and the station became isolated from other pools. DO then increased during and following a second storm event that increased flows to approximately 20 cfs and re-established surface flows between the isolated pools. DO declined briefly during the first of two perched events in November, but recovered before and during the second perched event. DO concentrations finally increased to approximately 10 mg/L once larger storm events increased flows above 100 cfs at the end of November (Figure 4.1.27).

The Villa Grande station had a mean DO concentration of 8.0 mg/L, a maximum concentration of 12.0 mg/L (132%), and a minimum concentration of 2.6 mg/L (Table 4.1.1). Supersaturation was observed as spring flows receded in May. Minimum concentrations were observed during perched conditions in June and open conditions in July and August when flows were approximately 100 cfs. Concentrations increased at the end of August, even though flows remained at about 110 cfs. DO response to perched conditions was variable. Concentrations declined to hypoxic levels during the first and second perched events in June and recovered as the river reopened. Conversely, DO concentrations increased during the fourth perched event in July and again during a perched event in November, however increasing flows from storm events may have also contributed to changes DO concentrations at the time (Figure 4.1.28).

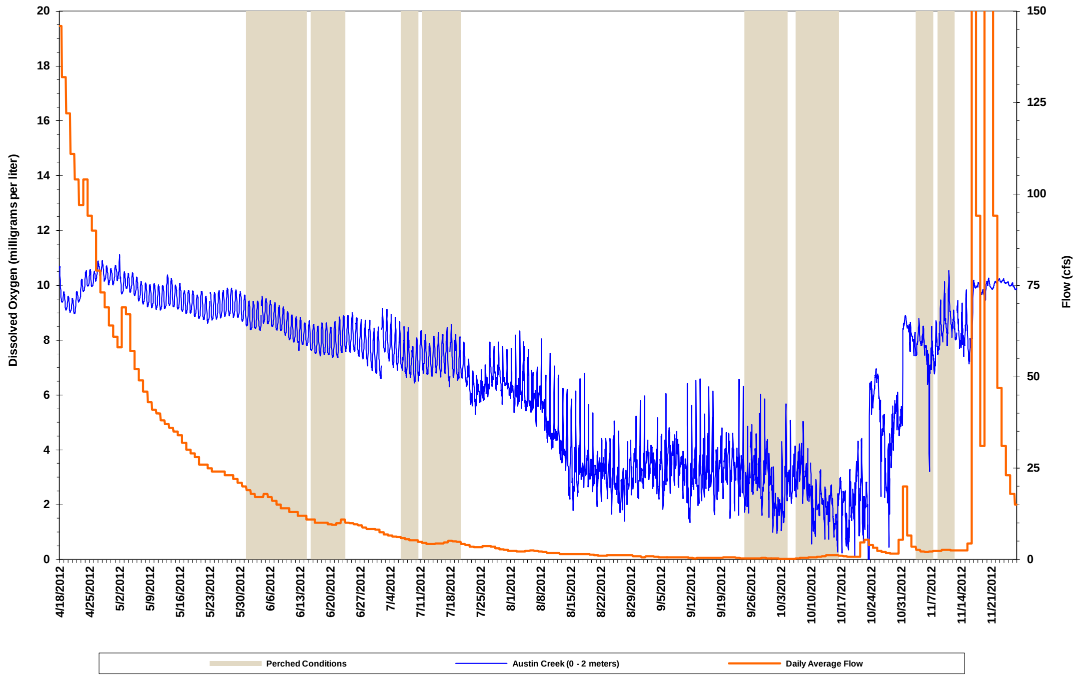

Figure 4.1.27. 2012 Austin Creek Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

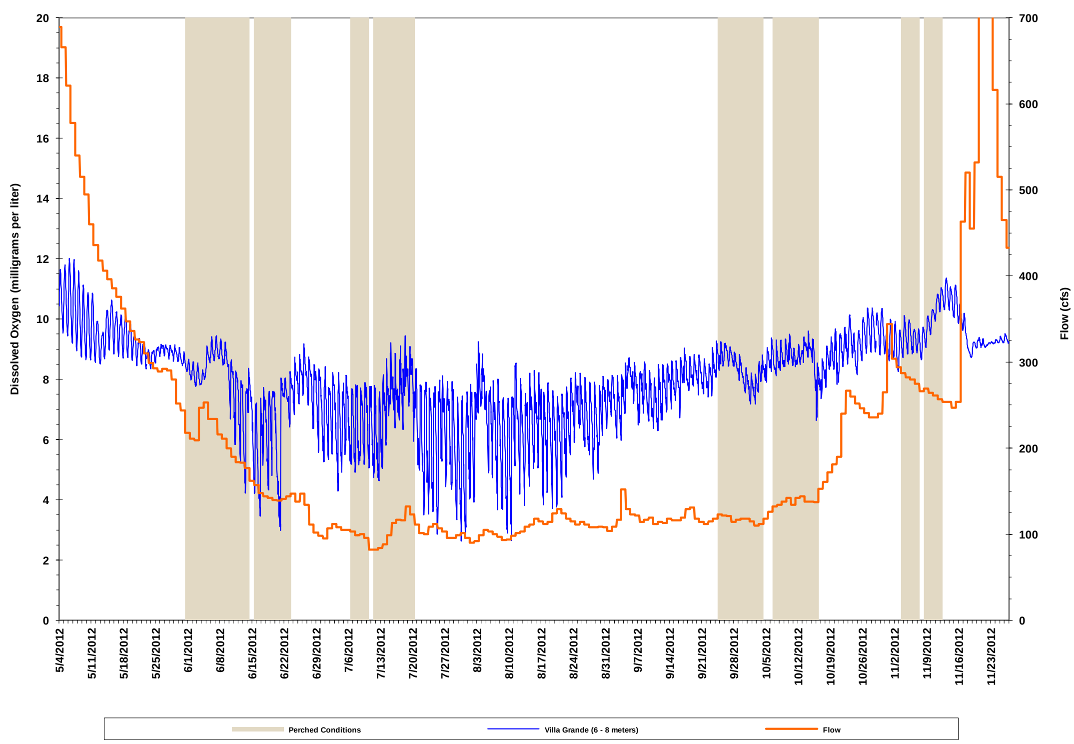

Figure 4.1.28. 2012 Russian River at Villa Grande Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

The Monte Rio Station had a DO concentration of 8.8 mg/L, a maximum concentration of 10.4 mg/L (125%), and a minimum concentration of 7.1 mg/L (Table 4.1.1). Minimum concentrations occurred during perched conditions in June and open conditions in August. However, DO concentrations did not appear to be significantly affected by summer flows or perched conditions and remained above 8 mg/L, on average, during both open and perched conditions (Figure 4.1.29).

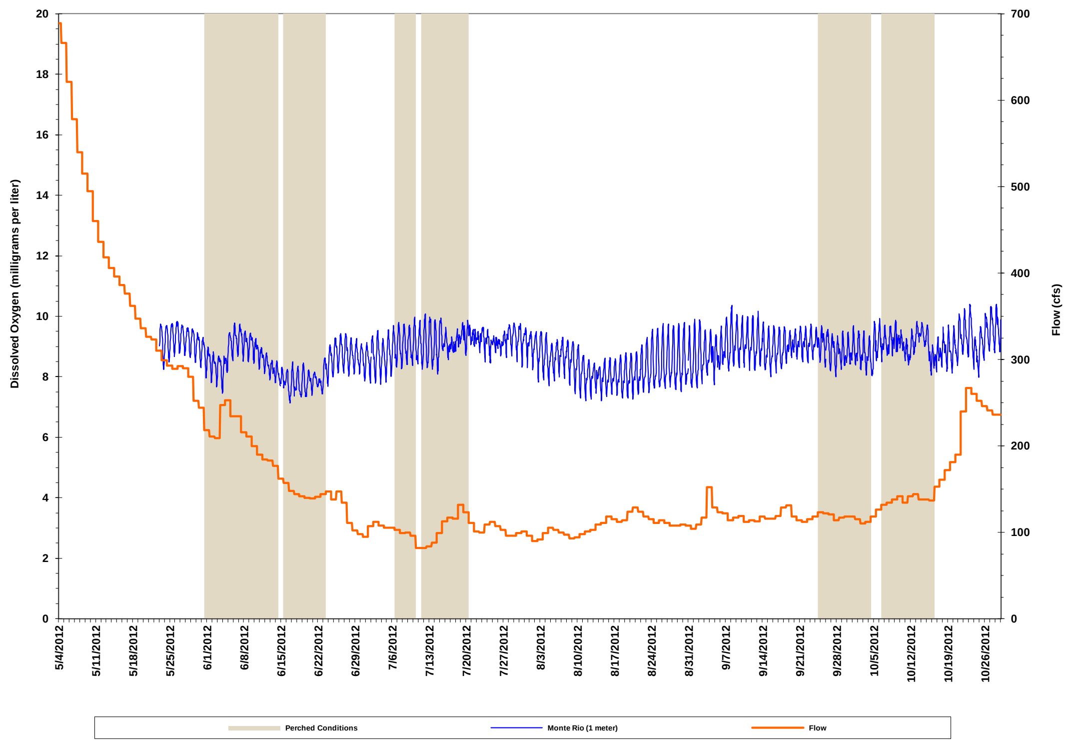

Figure 4.1.29. 2012 Russian River at Monte Rio Station dissolved oxygen. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Hydrogen Ion (pH)

The acidity or alkalinity of water is measured in units called pH, on an exponential scale of 1 to 14 (Horne 1994). Acidity is controlled by the hydrogen ion H^+, and pH is defined as the negative log of the hydrogen ion concentration. A pH value of 7 is considered neutral, freshwater streams generally remain at a pH between 6 and 9, and ocean derived salt water is usually at a pH between 8 and 9. When the pH falls below 6 over the long term, there is a noticeable reduction in the abundance of many species, including snails, amphibians, crustacean zooplankton, and fish such as salmon and some trout species (Horne 1994).

Lower and Middle Reaches

Hydrogen ion (pH) values were fairly consistent among all mid-depth stations in the lower and middle reaches, with a mean value of 7.9 pH observed at the Mouth, Patty's Rock, and Sheephouse Creek (Figures 4.1.30 through 4.1.32). The surface sondes were also consistent with a mean value of 8.3 pH at the Mouth and 8.2 at Patty's Rock

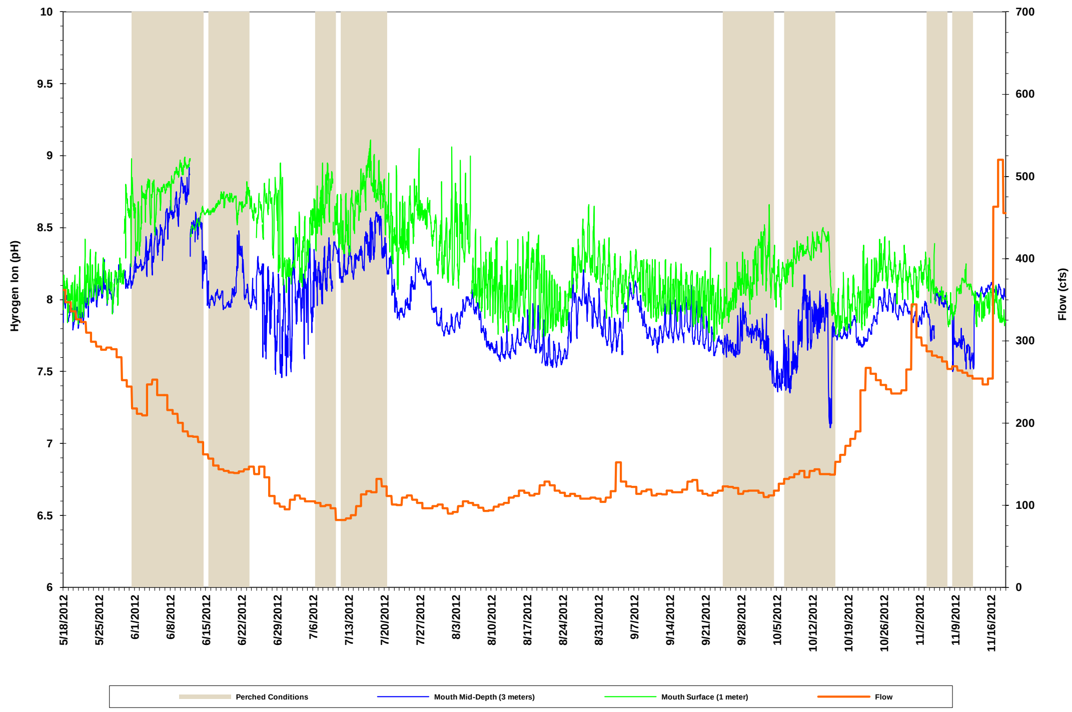

Figure 4.1.30. 2012 Russian River Mouth Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

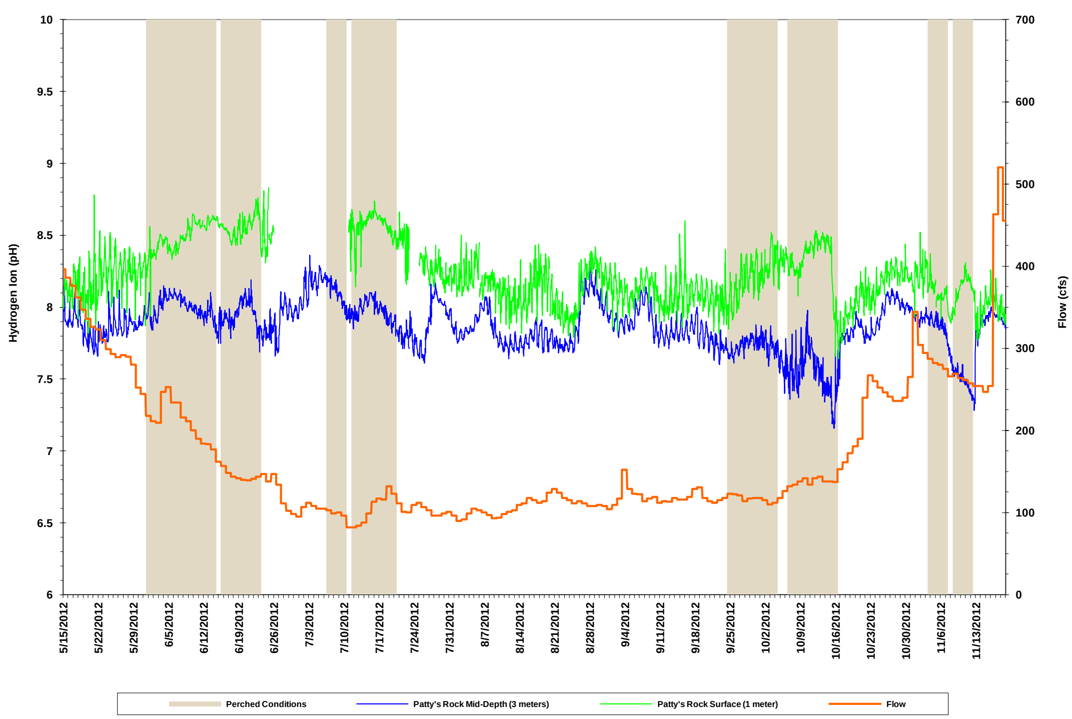

Figure 4.1.31. 2012 Russian River at Patty's Rock Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

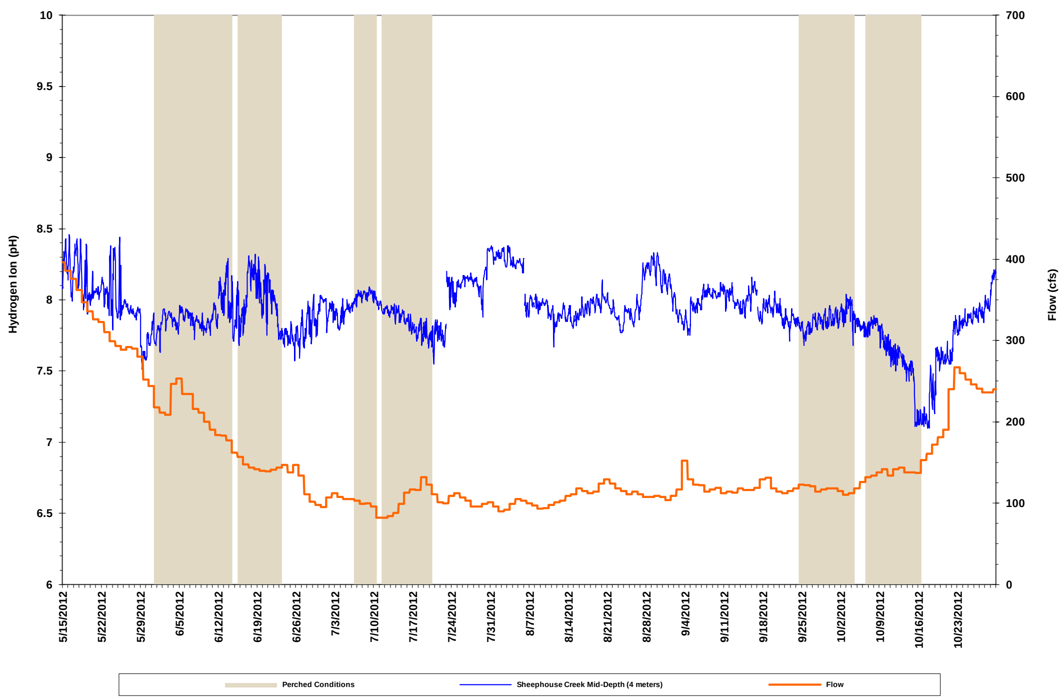

Figure 4.1.32. 2012 Russian River at Sheephouse Creek Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

(Table 4.1.1). Maximum pH values in the lower and middle reaches ranged from 8.4 to 9.1 and minimum pH values ranged from 7.1 to 7.7 (Table 4.1.1). Values were generally higher at the surface sondes when compared to the mid-depth sondes, especially during open estuary conditions (Figures 4.1.30 and 4.1.31). The lower and middle reach stations had pH values that varied with DO concentrations, with higher values observed during superstation conditions and lower values during hypoxic conditions (Figures 4.1.22 and 4.1.31 for examples).

The Willow Creek station had a mean pH value of 7.5, a maximum pH value of 9.1, and a minimum pH value of 6.5 (Table 4.1.1). The Willow Creek station also had pH values that varied with DO concentrations, with higher values observed during supersaturation conditions and lower values during hypoxic conditions (Figures 4.1.24 and 4.1.33). An exception to this was seen during increased flows in the fall. When increased fresh water flows from Willow Creek decreased the salinity and the temperature, accordingly, the pH values decreased as well, even though the DO was increasing.

Upper Reach

Hydrogen ion (pH) values at the Heron Rookery and Freezeout Creek bottom sondes were fairly consistent. The Heron Rookery and Freezeout Creek bottom sondes both had a mean pH value of 6.9, maximum pH values of 8.5 and 8.4, and minimum pH values of 6.2 and 5.8, respectively (Table 4.1.1). The Heron Rookery mid-depth sonde

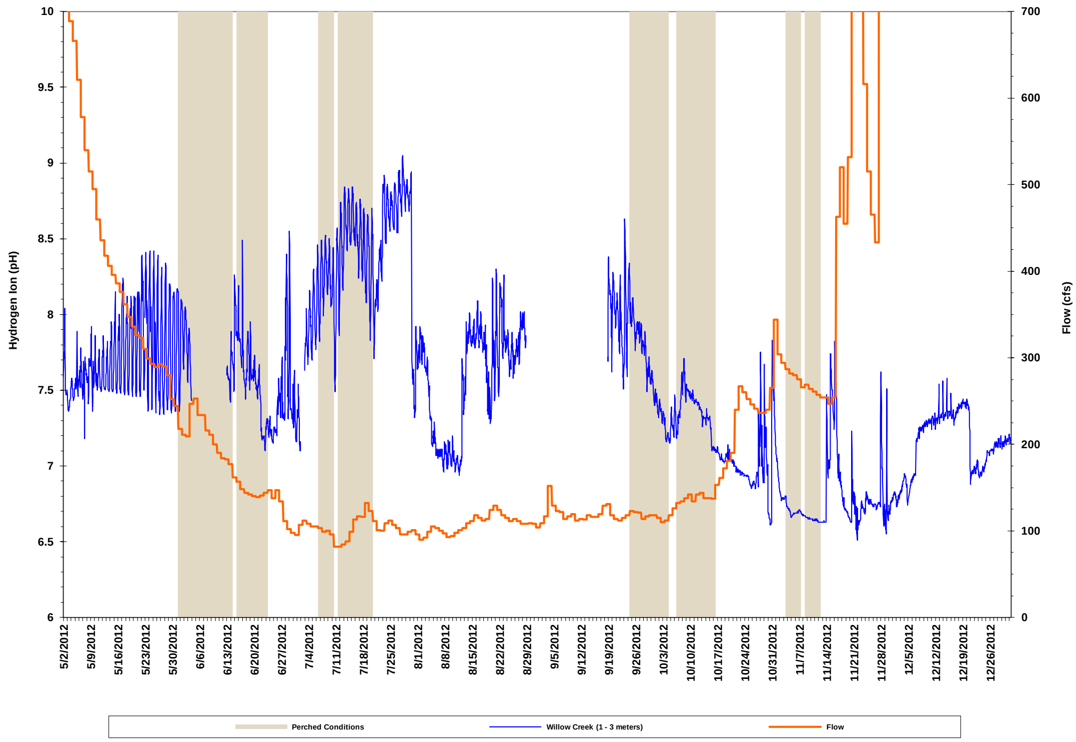

Figure 4.1.33. 2012 Willow Creek Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

had higher pH values compared to the bottom sondes, with a mean value of 7.7, a maximum value of 8.9, and a minimum value of 6.7 (Figures 4.1.34 and 4.1.35).

The upper reach stations also had pH values that varied with DO concentrations, with higher values observed during supersaturation conditions and lower values during hypoxic conditions (see Figures 4.1.25 and 4.1.34 for example). Lower minimum values were generally observed to occur during hypoxic and anoxic conditions in the presence of saline water. The Heron Rookery mid-depth sonde did not experience hypoxic and anoxic conditions with as much frequency as the bottom sondes, resulting in higher minimum pH values at the mid-depth sonde (Table 4.1.1).

Maximum Backwater Area

The Austin Creek station had a mean pH value of 7.7, a maximum pH value of 8.4, and a minimum pH value of 7.2 (Table 4.1.1). The Austin Creek station also had pH values that were generally observed to vary with increases and decreases of DO concentrations (Figures 4.1.27 and 4.1.36). Minimum values were observed during both perched and open conditions in September and October while flow was intermittent and DO levels were depressed in the isolated pool (Figure 4.1.36).

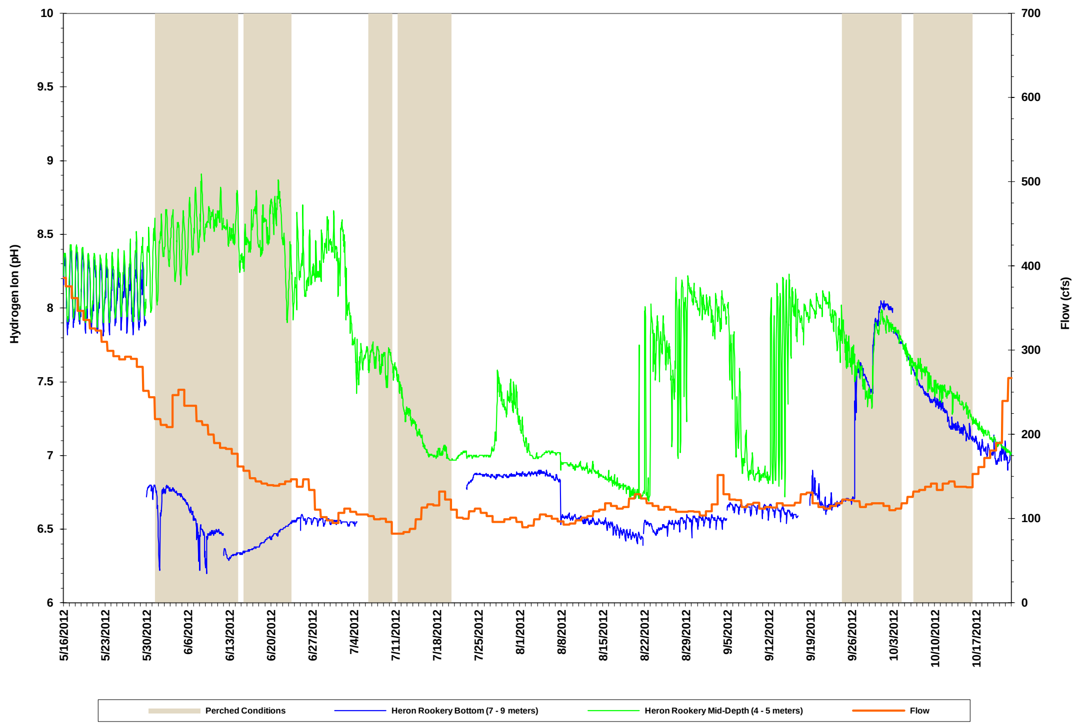

Figure 4.1.34. 2012 Russian River at Heron Rookery Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

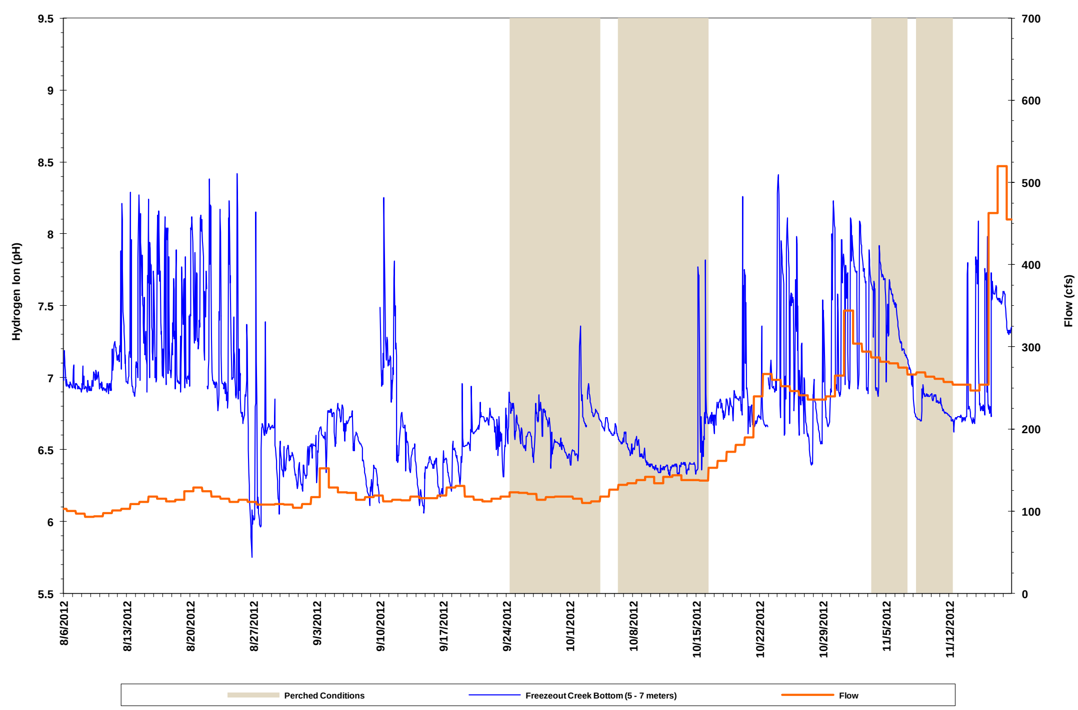

Figure 4.1.35. 2012 Russian River at Freezeout Creek Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

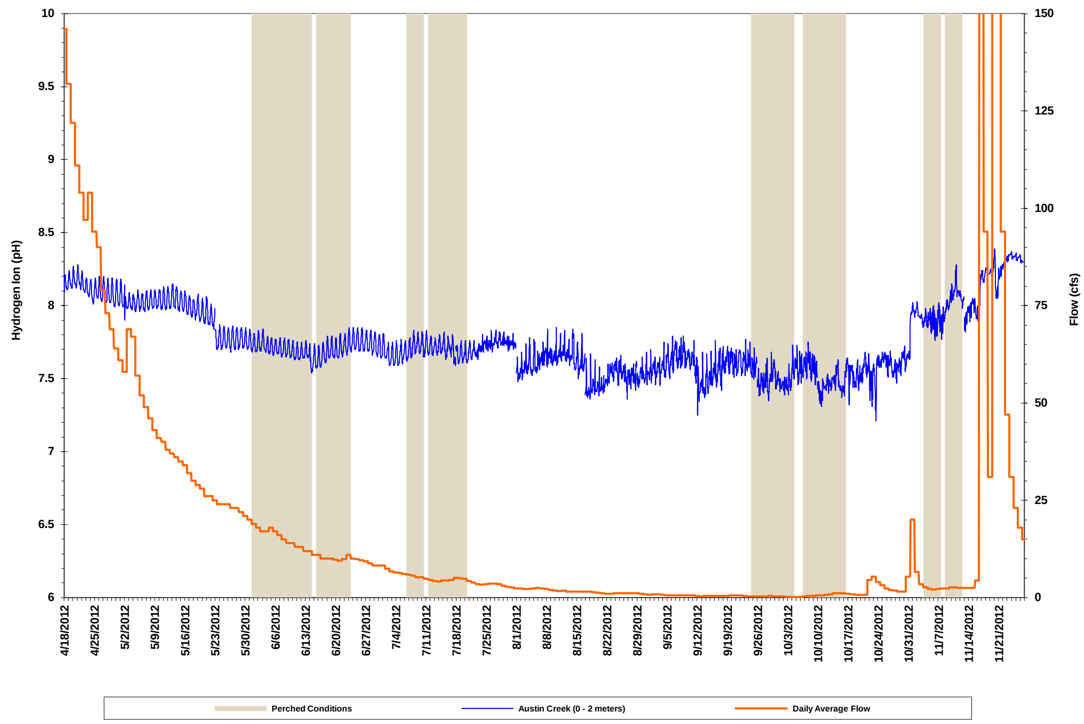

Figure 4.1.36. 2012 Austin Creek Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

The Villa Grande and Monte Rio stations similar pH values (Table 4.1.1). These stations had pH values that generally varied with DO concentrations. At Villa Grande, pH minimum values were observed during open conditions in July and August when DO levels were depressed (Figures 4.1.28 and 4.1.37). The Monte Rio station had pH values that generally varied with DO concentrations also, with maximum values observed in May (Figures 4.1.29 and 4.1.38).

Grab Sampling

Grab Sampling was conducted at five mainstem stations from Jenner to Monte Rio (Figure 4.1.1). Duplicate samples, and triplicate samples for pathogens, were also collected at the Monte Rio Station. Sampling was generally conducted every two weeks from 22 May to 9 October, when flows were above 125 cfs and the estuary was open. Sampling was increased to weekly starting 17 July when flows dropped and remained consistently below 125 cfs. Additional sampling was conducted during summer dam removal in October (Tables 4.1.2-4.1.7). Samples collected and analyzed for nutrients, *chlorophyll a*, and indicator bacteria are discussed below. Other sample results including organic carbon, dissolved solids, and turbidity are not discussed, but are included in Appendix A-6. Grab sampling for the same constituents was also conducted weekly at six stations in the mainstem of the Russian River from Hopland to Hacienda. Results from this sampling are not discussed in this report, but are also included in Appendix A-6.

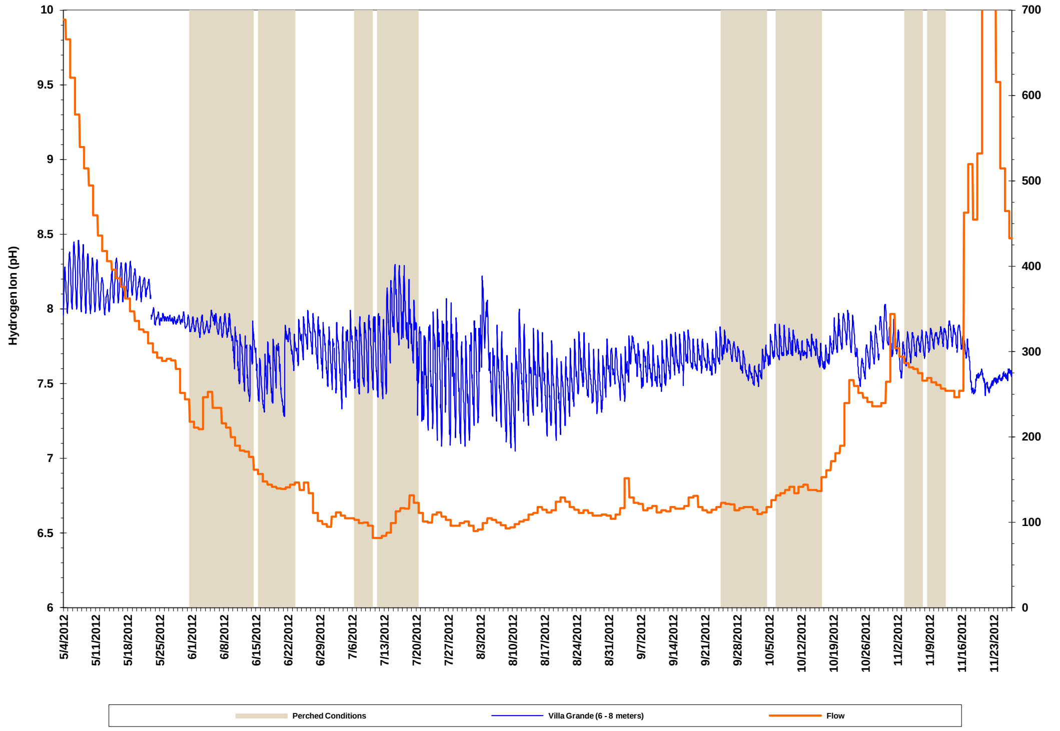

Figure 4.1.37. 2012 Russian River at Villa Grande Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

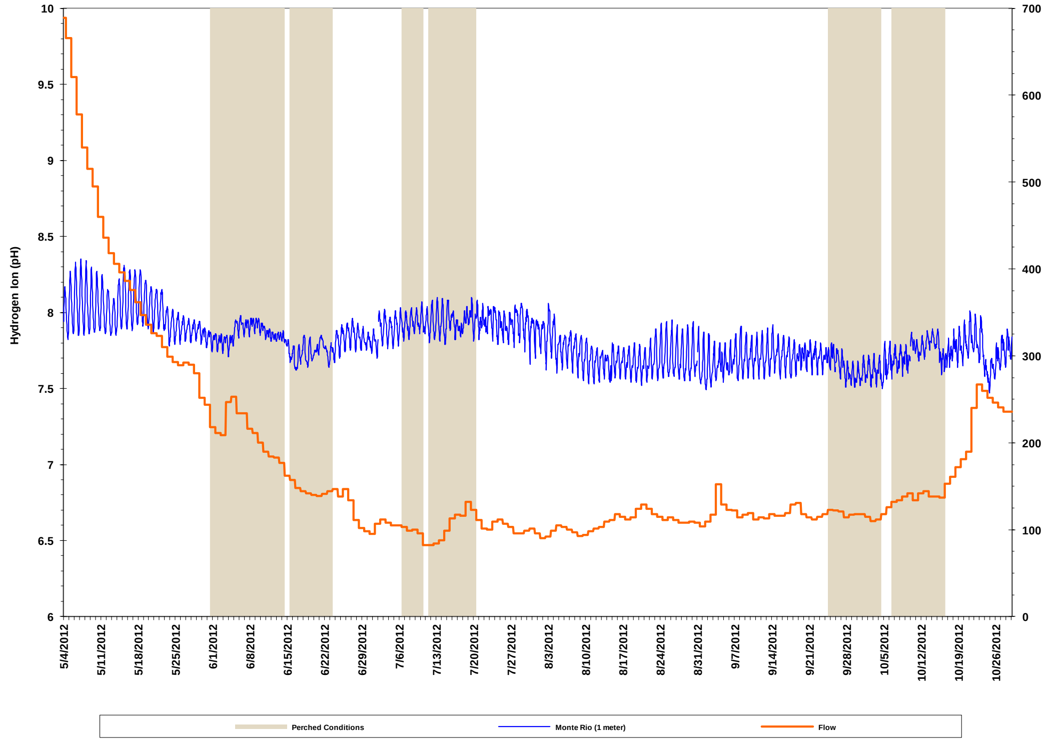

Figure 4.1.38. 2012 Russian River at Monte Rio Station hydrogen ion (pH) values. Flow in cubic feet per second (cfs) from United State Geological Survey gage at Hacienda station 11467000.

Nutrients

The United States Environmental Protection Agency (USEPA) has established section 304(a) nutrient criteria across 14 major ecoregions of the United States. The Russian River was designated in Aggregate Ecoregion III (USEPA 2013a). USEPA's section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA 2013b). The following discussion of nutrients compares sampling results to these USEPA criteria. However, it is important to note that these criteria are established for freshwater systems, and as such, are only applicable to the freshwater portions of the Estuary. Currently, there are no numeric nutrient criteria established specifically for estuaries.

The USEPA desired goal for total nitrogen in Aggregate Ecoregion III is 0.38 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA 2000). Calculating total nitrogen values requires the summation of the different components of total nitrogen; organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN), and nitrate/nitrite nitrogen (Appendix A-6). Often times, nitrogen constituent results were reported as less than the Method Detection Limit (MDL). In these instances, the MDL for the non-detected (ND) constituent is used for the purposes of calculating total nitrogen estimates, and the total nitrogen value is considered less than the estimate.

Total nitrogen concentrations were observed to exceed levels recommended for the protection of freshwater aquatic habitats predominantly at Jenner and Bridgehaven (both located in the lower reach of the Estuary), and periodically at Duncans Mills, Casini Ranch and Monte Rio in the upper reach (Tables 4.1.2 to 4.1.7). Exceedances of the total nitrogen criteria were observed to occur during open and perched conditions, with the majority of freshwater standards exceedances being observed at the Jenner Station. Exceedances were observed to occur throughout the monitoring period and under a variety of flows that ranged from a daily average of 100 cubic feet per second (cfs) to 323 cfs. The number of total nitrogen exceedances varied from station to station, with a low of no exceedances at the Monte Rio Duplicate Station (Table 4.1.7) to a high of 12 exceedances at the Jenner Station (Table 4.1.2). Jenner was observed to have four exceedances equal to or greater than 1 mg/L, with a high value of 1.5 mg/L on 28 August during open river mouth (tidal) conditions (Table 4.1.2). Bridgehaven was observed to have a maximum concentration of 0.80 mg/L that was collected on 21 August also during open conditions (Table 4.1.3). The Duncans Mills Station had three exceedances, including a high value of 3.4 mg/L on 17 July under perched conditions (Table 4.1.4). Casini Ranch had one exceedance with a value of 0.54 mg/L (Table 4.1.5). The Monte Rio Station was observed to have a maximum concentration of 0.77 mg/L that was collected on 17 July during perched conditions, whereas the Monte Rio Duplicate Station had a concentration of 0.14 mg/L on the same day (Tables 4.1.6 and 4.1.7).

Table 4.1.2. 2012 Jenner Station grab sample (nutrients and bacteria) results.

Jenner Boat Ramp*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	17.9	**0.90**	**0.053**	**6.5**	**0.0019**	--	--	--	323	open
6/5/2012	18.3	0.28	**0.022**	1.6	0.0013	1732.9	127.4	**547.5**	253	perched
6/19/2012	20.5	0.35	**0.034**	1.4	**0.0023**	>2419.6	137.6	**157.6**	142	perched
7/3/2012	20.4	0.28	0.020	1.2	0.00021	2419.8	143.9	51.2	112	open
7/17/2012	18.5	**0.65**	**0.024**	1.7	0.0014	>2419.6	30.5	**648.8**	117	perched
7/24/2012	19.6	**0.50**	**0.026**	1.9	0.00069	>2419.6	3.0	23.8	109	open
7/31/2012	19.2	**0.47**	**0.026**	1.2	ND	>2419.6	59.1	**613.1**	101	open
8/7/2012	18.2	**0.48**	**0.027**	1.4	**0.0027**	>2419.6	<1.0	54.6	100	open
8/14/2012	18.0	**1.4**	**0.030**	1.4	0.0014	>2419.6	3.0	**275.5**	109	open
8/21/2012	17.7	**1.4**	**0.022**	0.76	0.0015	>2419.6	54.1	**62**	129	open
8/28/2012	17.3	**1.5**	**0.025**	0.92	**0.0030**	>2419.6	34.2	21.8	108	open
9/4/2012	16.5	**0.88**	**0.025**	1.1	0.0013	165.0	3.1	43.2	152	open
9/11/2012	16.8	0.21	**0.026**	0.72	0.0011	>2419.6	3.1	11	112	open
9/18/2012	15.5	0.21	**0.026**	0.65	0.00098	2419.6	2.0	10.9	129	open
9/25/2012	14.8	**0.49**	ND	0.73	0.00073	>2419.6	1.0	15.8	123	perched
10/2/2012	15.7	0.32	**0.022**	0.83	0.00078	980.4	33.6	21.8	115	perched
10/4/2012	17.9	**1.0**	**0.027**	1.3	**0.0020**	816	9.8	12.1	112	perched
10/9/2012	15.3	**0.39**	0.021	1.3	0.0013	360.9	45.5	**71.2**	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.3. 2012 Bridgehaven Station grab sample (nutrients and bacteria) results.

Bridgehaven*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	18.8	0.28	**0.038**	2.2	0.001	>2419.6	10.1	--	323	open
6/5/2012	18.5	0.34	0.020	0.89	0.00027	980.4	75.4	**121.1**	253	perched
6/19/2012	20.6	0.28	**0.036**	1.1	0.00041	1119.9	22.6	19.7	142	perched
7/3/2012	19.9	0.35	**0.046**	2.1	0.00032	>2419.8	20.1	2.0	112	open
7/17/2012	18.8	**0.51**	**0.077**	1.1	0.0015	>2419.6	14.1	17.5	117	perched
7/24/2012	20.0	0.21	0.020	1.8	0.00057	>2419.6	8.6	24.1	109	open
7/31/2012	19.9	**0.41**	**0.026**	1.2	ND	>2419.6	24.1	53.7	101	open
8/7/2012	21.0	0.28	**0.029**	**2.6**	0.0012	>2419.6	<1.0	13.2	100	open
8/14/2012	19.2	**0.78**	ND	0.84	0.00012	>2419.6	2.0	**146.4**	109	open
8/21/2012	19.5	**0.80**	ND	0.79	0.0010	>2419.6	21.2	58.3	129	open
8/28/2012	19.4	0.21	**0.040**	0.64	**0.0018**	2419.6	10.2	23.5	108	open
9/4/2012	17.0	0.21	ND	0.71	0.0017	2419.6	3.1	26.2	152	open
9/11/2012	17.8	0.21	**0.025**	0.69	**0.0025**	>2419.6	1.0	19.9	112	open
9/18/2012	17.2	0.35	**0.028**	0.64	**0.0022**	>2419.8	6.3	5.2	129	open
9/25/2012	16.1	0.24	ND	1.2	0.0017	2419.6	3.0	16.1	123	perched
10/2/2012	16.8	0.24	**0.023**	0.90	**0.0019**	365.4	16.0	5.2	115	perched
10/4/2012	17.8	**0.58**	**0.035**	1.1	**0.0039**	>2419.6	186	**201.4**	112	perched
10/9/2012	15.7	0.18	**0.025**	0.94	**0.0019**	1046.2	**461.1**	**365.4**	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.4. 2012 Duncans Mills Station grab sample (nutrients and bacteria) results.

Duncans Mills*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	20.3	0.21	0.020	0.62	0.0010	1046.2	13.2	--	323	open
6/5/2012	20.8	0.31	**0.029**	0.86	0.0013	2419.6	29.2	14.5	253	perched
6/19/2012	22.1	0.32	**0.034**	0.91	0.00062	461.1	60.5	10.8	142	perched
7/3/2012	23.6	0.32	**0.035**	1.0	0.00053	980.4	27.2	5.2	112	open
7/17/2012	21.3	**3.4**	**0.037**	1.1	0.00035	1986.3	30.1	12.1	117	perched
7/24/2012	22.4	**0.47**	**0.027**	1.2	0.00046	1986.3	4.1	10.7	109	open
7/31/2012	22.7	0.33	**0.069**	1.1	ND	1203.3	8.5	9.5	101	open
8/7/2012	21.6	**0.38**	**0.031**	**2.7**	0.0012	>2419.6	12.0	18.9	100	open
8/14/2012	21.1	0.30	**0.029**	1.1	0.00086	>2419.6	15.8	24.3	109	open
8/21/2012	21.4	0.24	**0.024**	0.86	0.00092	1553.3	3.1	2.0	129	open
8/28/2012	21.1	0.33	0.020	0.61	0.0011	1299.7	6.3	6.3	108	open
9/4/2012	20.1	0.21	**0.029**	1.6	0.00085	2419.6	8.5	7.3	152	open
9/11/2012	19.3	0.14	0.021	0.73	0.00014	1986.3	10.8	13.7	112	open
9/18/2012	19.2	0.18	0.021	0.59	ND	1732.9	10.8	13.4	129	open
9/25/2012	17.9	0.18	ND	1.3	ND	461.1	14.6	22.8	123	perched
10/2/2012	18.6	0.28	**0.027**	0.90	ND	1732.9	45.7	28.2	115	perched
10/4/2012	19.1	0.24	**0.029**	1.0	0.00013	866.4	12.2	26.6	112	perched
10/9/2012	17.2	0.31	ND	0.79	0.00013	770.1	8.5	7.5	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.5. 2012 Casini Ranch Station grab sample (nutrients and bacteria) results.

Casini Ranch*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	21.2	0.21	ND	0.81	**0.0065**	1553.1	6.0	--	323	open
6/5/2012	21.0	0.18	**0.026**	1.0	**0.0020**	980.4	26.2	11.9	253	perched
6/19/2012	22.4	0.21	**0.040**	1.2	0.0014	1299.7	49.5	**248.9**	142	perched
7/3/2012	23.2	0.33	**0.027**	1.2	0.00074	980.4	12.1	38	112	open
7/17/2012	21.7	0.28	**0.032**	0.95	0.00012	1046.2	6.3	8.5	117	perched
7/24/2012	22.1	0.29	**0.030**	1.1	0.00023	1046.2	<1.0	3.0	109	open
7/31/2012	22.8	**0.54**	**0.026**	1.1	ND	920.8	5.2	4.1	101	open
8/7/2012	22.3	0.18	**0.035**	**2.4**	0.0011	>2419.6	5.2	6.2	100	open
8/14/2012	21.5	0.18	**0.029**	1.2	0.0014	1553.1	7.5	7.4	109	open
8/21/2012	22.3	0.18	**0.025**	1.0	0.0011	1986.3	<1.0	5.1	129	open
8/28/2012	21.8	0.18	**0.027**	0.70	0.00054	1046.2	5.2	6.3	108	open
9/4/2012	20.6	0.14	**0.026**	1.4	0.00099	1203.3	4.1	4.1	152	open
9/11/2012	20.5	0.18	ND	0.74	ND	1046.2	8.6	5.1	112	open
9/18/2012	19.3	0.36	**0.025**	0.62	ND	980.4	7.5	6.3	129	open
9/25/2012	18.3	0.18	ND	1.0	ND	866.4	17.3	26.2	123	perched
10/2/2012	19.1	0.14	**0.022**	1.0	ND	866.4	20.1	44.8	115	perched
10/4/2012	19.1	0.24	**0.037**	1.4	0.00025	613.1	15.5	21.3	112	perched
10/9/2012	18.1	0.18	ND	0.90	0.00013	648.8	6.3	11.0	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.6. 2012 Monte Rio Station grab sample (nutrients and bacteria) results.

Monte Rio*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	20.3	0.24	**0.030**	1.3	**0.0090**	>2419.6	7.0	--	323	open
6/5/2012	20.1	0.36	**0.033**	1.5	0.0015	1732.9	37.9	22.8	253	perched
6/19/2012	23.0	0.28	**0.035**	1.4	**0.0023**	1986.3	55.6	8.4	142	perched
7/3/2012	24.2	0.18	**0.027**	1.5	0.00084	1986.3	18.5	**164.8**	112	open
7/17/2012	22.3	**0.77**	**0.029**	1.3	0.00012	866.4	13.4	14.6	117	perched
7/24/2012	23.2	0.18	**0.023**	1.5	0.00080	1203.3	8.3	**77.2**	109	open
7/31/2012	23.6	0.33	**0.026**	0.91	ND	1986.3	6.3	1.0	101	open
8/7/2012	22.6	0.14	0.021	0.85	0.00082	1203.3	6.3	2.0	100	open
8/14/2012	22.6	ND	ND	1.0	0.00074	1553.1	10.9	9.6	109	open
8/21/2012	22.3	0.14	**0.024**	0.88	0.00080	1203.3	9.7	29.5	129	open
8/28/2012	21.8	0.18	**0.023**	0.74	ND	1553.1	7.3	7.3	108	open
9/4/2012	21.0	0.32	**0.026**	1.2	0.00042	1732.9	6.3	2.0	152	open
9/11/2012	20.2	0.18	**0.023**	0.70	0.00014	1299.7	2.0	7.5	112	open
9/18/2012	19.1	0.14	ND	0.63	ND	727	3.1	8.5	129	open
9/25/2012	18.0	0.18	ND	0.8	ND	410.6	9.7	14.6	123	perched
10/2/2012	18.7	0.31	**0.036**	0.93	0.00039	727.0	6.3	12.2	115	perched
10/4/2012	19.0	0.18	**0.027**	0.98	ND	365.4	5.2	12.1	112	perched
10/9/2012	16.9	0.14	**0.024**	0.85	ND	275.5	20.1	4.1	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

Table 4.1.7. 2012 Monte Rio Duplicate Station grab sample (nutrients and bacteria) results.

Monte Rio (Duplicate)*	Temperature	Total Nitrogen***	Phosphorus, Total	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda****	
MDL**			0.020	0.020	0.000050	20	20	2	Flow Rate	Estuary
Date	°C	mg/L	mg/L	NTU	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	20.3	0.21	0.028	1.3	0.0090	2419.6	4.0	--	323	open
6/5/2012	20.1	0.33	0.031	1.3	0.0014	1732.9	22.8	20.1	253	perched
6/19/2012	23.0	0.32	0.034	1.4	0.0020	2419.6	60.5	16.9	142	perched
7/3/2012	24.2	0.21	0.027	1.4	0.0017	1413.6	24.3	79.0	112	open
7/17/2012	22.3	0.14	0.031	1.3	0.00023	727	13.4	13.4	117	perched
7/24/2012	23.2	0.18	0.027	1.4	0.00069	1299.7	8.6	56.8	109	open
7/31/2012	23.6	0.21	0.024	0.84	ND	2419.6	4.1	1.0	101	open
8/7/2012	22.6	0.18	0.021	0.84	0.00094	1299.7	6.3	2.0	100	open
8/14/2012	22.6	0.26	0.021	1.0	0.00025	1413.6	7.4	7.3	109	open
8/21/2012	22.3	0.10	0.021	0.86	0.00046	1986.3	11	22.6	129	open
8/28/2012	21.8	0.14	ND	0.73	0.00095	1203.3	7.5	7.3	108	open
9/4/2012	21.0	ND	0.021	1.3	0.00056	1533.1	3.1	2.0	152	open
9/11/2012	20.2	0.18	0.022	0.76	0.00014	1413.6	4.1	4.1	112	open
9/18/2012	19.1	0.25	ND	0.69	ND	1203.3	5.2	10.9	129	open
9/25/2012	18.0	0.18	ND	0.83	ND	579.4	7.5	12.1	123	perched
10/2/2012	18.7	0.32	0.034	0.96	0.00013	613.1	6.3	8.6	115	perched
10/4/2012	19.0	0.14	0.029	0.77	ND	517.2	5.2	4.1	112	perched
10/9/2012	16.9	0.10	0.026	0.72	0.00025	365.4	19.7	2.0	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

**** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

The USEPA's desired goal for total phosphates as phosphorus in Aggregate Ecoregion III has been established as 21.88 micrograms per liter (µg/L), or approximately 0.022 mg/L, for rivers and streams not discharging into lakes or reservoirs (USEPA 2000). Total phosphorus concentrations exceeded the USEPA criteria a majority of the time at all five stations in the Estuary during both open and perched conditions and under a variety of flows. Measureable levels of total phosphorus were as high as 0.077 mg/L at the Bridgehaven Station on 17 July during perched conditions, and 0.069 mg/L at the Duncans Mills Station on 31 July during open tidal conditions. By contrast, all of the stations also had at least one non-detect (ND) sample collected during open and perched conditions and flows that ranged from 108 to 323 cfs (Tables 4.1.2 – 4.1.7).

Chlorophyll a

In the process of photosynthesis, *Chlorophyll a* - a green pigment in plants, absorbs sunlight and combines carbon dioxide and water to produce sugar and oxygen. *Chlorophyll a* can therefore serve as a measureable parameter of algal growth. Qualitative assessment of primary production on water quality can be based on

Chlorophyll a concentrations. A U.C. Davis report on the Klamath River (1999) assessing potential water quality and quantity regulations for restoration and protection of anadromous fish in the Klamath River includes a discussion of *Chlorophyll a* and how it can affect water quality. The report characterizes the effects of *Chlorophyll a* in terms of different levels of discoloration (e.g., no discoloration to some, deep, or very deep discoloration). The report indicated that less than 10 µg/L (or 0.01 mg/L) of *Chlorophyll a* exhibits no discoloration (Deas and Orlob 1999). Additionally, the USEPA criterion for *Chlorophyll a* in Aggregate Ecoregion III is 1.78 µg/L, or approximately 0.0018 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA 2000). However, it is important to note that the EPA criterion is established for freshwater systems, and as such, is only applicable to the freshwater portions of the Estuary. Currently, there are no numeric *Chlorophyll a* criteria established specifically for estuaries.

Chlorophyll a concentrations were less than 0.01 mg/L at all stations during the monitoring period, the level recommended to prevent discoloration of surface waters (Tables 4.1.2 – 4.1.6). The Monte Rio and Monte Rio Duplicate Stations were just below this concentration threshold with a value of 0.0090 mg/L collected at both stations on 22 May during open conditions and spring flows of 323 cfs (Tables 4.1.6 and 4.1.7).

Chlorophyll a concentrations were observed to remain below the USEPA criteria of 0.0018 mg/L a majority of the time at all stations. However there were exceedances observed at all stations except Duncans Mills, where there were no exceedances (Tables 4.1.2 – 4.1.7). All of the stations also had at least one non-detect (ND) sample collected during open and perched conditions and flows that ranged from 101 to 138 cfs. (Tables 4.1.2 – 4.1.7).

The Jenner Station was observed to have periodic exceedances throughout the season that occurred during open and closed conditions and flows that ranged from 100 to 323 cfs (Table 4.1.2). Exceedances at the Bridgehaven Station occurred in the latter half of the monitoring period during open and perched estuary conditions when flows were below 140 cfs (Table 4.1.3). Whereas, the Casini Ranch, Monte Rio, and Monte Rio Duplicate stations had exceedances at the beginning of the monitoring period during open and perched conditions while spring flows were still elevated (Tables 4.1.5 through 4.1.7). The highest recorded *Chlorophyll a* concentrations of the season occurred at the Monte Rio and Monte Rio Duplicate stations on 22 May during open conditions and elevated spring flows of 323 cfs (Table 4.1.6 and 4.1.7).

Indicator Bacteria

The California Department of Public Health (CDPH) developed the "Draft Guidance for Fresh Water Beaches," which describes bacteria levels that, if exceeded, may require posted warning signs in order to protect public health (CDPH 2011). The CDPH draft guideline for total coliform is 10,000 most probable numbers (MPN) per 100 milliliters (ml), 235 MPN per 100 ml for *E. coli*, and 61 MPN per 100 ml for *Enterococcus*. However, it must be emphasized that these are draft guidelines, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines are not accurate indicators) and are not currently enforceable. In addition, these draft guidelines were established for and are only applicable to fresh water beaches. Currently, there are no numeric guidelines that have been developed for estuarine areas.

E. coli was analyzed using the Colilert method and enterococcus was analyzed using the Enterolert method. Samples were not analyzed specifically for total coliforms, but concentrations are determined as part of the analytical process for determining *E. coli* concentrations and the results are included in the lab report. As such, it should be noted that the dilution rates that are utilized to accurately quantify *E. coli* concentrations for comparison to the draft guidelines do not allow for the quantification of total coliform concentrations at a high enough level to compare with the draft guidelines and are instead reported as greater than 2419.6 MPN (>2419.6). The decision to focus on *E. coli* and *Enterococcus* for the analysis of potential water quality impacts and not total coliform concentrations was done in coordination and consultation with Regional Board staff.

Sampling results in 2012 indicate there is a large variation in indicator bacteria levels observed through the different reaches of the Estuary (Tables 4.1.2 – 4.1.8). These variations occurred under both open and perched estuary conditions and a variety of flows, and may be seasonal as well.

The recommended *E. coli* guideline of 235 MPN/100 ml was only exceeded at the Bridgehaven Station. Bridgehaven had one count of 461.1 MPN that occurred on 9 October during perched conditions when flows were approximately 138 cfs (Table 4.1.2). Sampling stations were observed to have slightly higher values during perched conditions and elevated flows in the late spring and in the fall, although they were not high enough to exceed the recommended guideline.

All stations were observed to exceed the recommended *Enterococcus* guidelines at least once during the monitoring period, with the exception of the Duncans Mills Station (Tables 4.1.2 – 4.1.8). The draft guidance for freshwater beach posting identifies the potential for public health concerns when *Enterococcus* levels exceed 61 MPN/100ml. The Jenner Station had seven exceedances during perched and open conditions and flows that ranged from a high of 253 cfs in the spring to a low of 101 cfs in mid-summer. Five of the seven exceedances were above 150 MPN, including two that were above 600 MPN. A maximum count of 648.8 MPN was observed during perched conditions on 17 July and a count of 613.1 MPN was observed during open conditions on 31 July (Table 4.1.2). The Bridgehaven Station had four exceedances of the guideline, with three occurring during perched conditions and one during open conditions. The exceedances observed during perched conditions included a count of 121.1 MPN during elevated spring flows, and counts of 201.4 and 365.4 MPN in October when flows were elevated by summer dam removal (Table 4.1.3). The Duncans Mills Station

Table 4.1.8. 2012 Monte Rio Triplicate Station grab sample (bacteria) results.

Monte Rio (Triplicate)*	Temperature	Total Coliforms (Colilert)	E. coli (Colilert)	Enterococcus (Enterolert)	Hacienda***	
MDL**		20	20	2	Flow Rate	Estuary
Date	°C	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)	Condition
5/22/2012	20.3	1732.9	15.2	--	323	open
6/5/2012	20.1	1986.3	44.1	25.9	253	perched
6/19/2012	23.0	>2419.6	48.1	14.4	142	perched
7/3/2012	24.2	1986.3	9.8	59.3	112	open
7/17/2012	22.3	866.4	16.1	28.3	117	perched
7/24/2012	23.2	1413.6	10.8	**87.1**	109	open
7/31/2012	23.6	1986.3	8.4	2.0	101	open
8/7/2012	22.6	307.6	4.1	1.0	100	open
8/14/2012	22.6	1553.1	13.5	8.4	109	open
8/21/2012	22.3	1413.6	3.1	42.2	129	open
8/28/2012	21.8	1299.7	6.3	3.1	108	open
9/4/2012	21.0	1203.3	12.2	7.4	152	open
9/11/2012	20.2	1732.9	2.0	7.5	112	open
9/18/2012	19.1	980.4	7.5	17.3	129	open
9/25/2012	18.0	613.1	16.0	15.6	123	perched
10/2/2012	18.7	488.4	5.2	9.8	115	perched
10/4/2012	19.0	488.4	9.7	5.2	112	perched
10/9/2012	16.9	461.1	7.3	6.3	138	perched

* All results are preliminary and subject to final revision.

** Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors.

*** United States Geological Survey (USGS) 11467000 RR near Guerneville (Hacienda) Continuous-Record Gaging Station (Flow rates are preliminary and subject to final revision by USGS).

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values:

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

E. coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

had no exceedances of the recommended guideline. The Casini Ranch Station had a high count of 248.9 MPN on 19 June during perched conditions and declining spring flows (Table 4.1.5). The Monte Rio Station had a high count of 164.8 MPN on 3 July and another high count of 77.2 MPN on 24 July (Table 4.1.6). Both exceedances occurred during open conditions. In addition, the Monte Rio Duplicate Station had one high count of 79.0 MPN that occurred on 3 July and the Monte Rio Triplicate Station had one high count of 87.1 MPN that occurred on 24 July (Tables 4.1.7 and 4.1.8).

Conclusions and Recommendations

Overall, water quality conditions observed during the 2012 monitoring season were similar to conditions associated with a dynamic estuarine system observed in previous years. Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers in the Estuary. When the barrier beach forms, saltwater is trapped in the lagoon and water quality conditions can undergo abrupt alteration. Often times, salinity, DO and temperature changes can occur within 24 hours. After the estuary becomes stratified, the mid-depth saltwater lens traps heats (Entrix 2004). Through natural processes including reduced mixing, DO becomes depleted in the bottom saline layer and anoxic conditions can develop. Some notable observations associated with salinity migration, temperature, dissolved oxygen, nutrients, and indicator bacteria will be discussed further below.

Salinity concentrations were observed to periodically decrease in the lower and middle reaches of the estuary during muted tidal cycles and perched conditions. Muted tides and perched conditions occured in June and July and again in October and November (Figures 4.1.3 through 4.1.5). Muted tidal cycles were observed to occur during partial barrier beach formation when the river mouth was somewhat isolated from ocean swells by the Jetty (Photo 4.1.1). Perched conditions typically developed as the orientation of the Jetty also acted as a barrier to tidal action and salinity intrusion into the estuary (Photo 4.1.2). During perched conditions, the freshwater lens deepened at the Mouth and Patty's Rock surface stations. Salinity levels also decreased at mid-depth at these stations during perched conditions. Some of that saltwater was migrating into the lower half of the water column in the upper reach as the salt layer was stratifying and flattening out. However, decreases in salinity at the Mouth and Patty's Rock stations may also be evidence that the denser saltwater was percolating out of the Estuary through the barrier beach and contributing to the partial formation of freshwater lagoon conditions.

In 2012, like 2011, it appeared that less sand was deposited immediately behind the jetty during long period swells in relation to the rest of the barrier beach, resulting in a low point that allowed muted tidal cycles to occur. However, muted tidal cycles in 2012 were fairly short-lived and associated with perching events, whereas muted tidal cycles in 2011 occurred more frequently and were not always associated with perching events. As a result, there was significantly more salinity migration into the upper reach in 2012 than in 2011 as seen in a comparison of conditions during both years at the Freezeout Creek station (Figure 4.1.39). This occurred even though there were no closures or perched events in 2011 until September of that year (SCWA 2012). Mid-season base flows were slightly lower in 2012 than they were in 2011, which also may have contributed to the difference in the degree of salinity migration into the upper reach (Figure 4.1.39). However, the Freezeout Creek station was not installed until early August, so the transition from freshwater to brackish that typically occurs in late spring was not recorded.

The Heron Rookery station was installed by mid-May during both years and a comparison can be made between years for the transition from freshwater to saline. In 2012, saltwater was observed to migrate to the Heron Rookery bottom sonde on 30 May, where it remained above 20 ppt for the rest of the season (Figure 4.1.40).

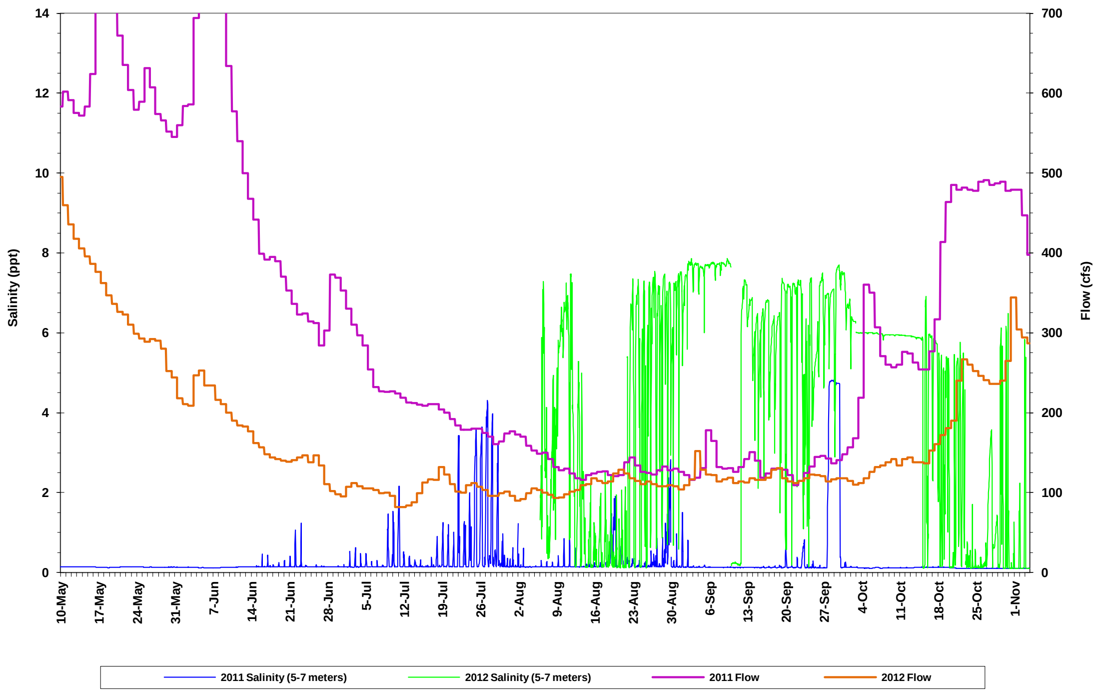

Figure 4.1. 39. Comparison of salinity and flow in the Russian River estuary for the years 2011 and 2012 at the Freezeout Creek Bottom Station.

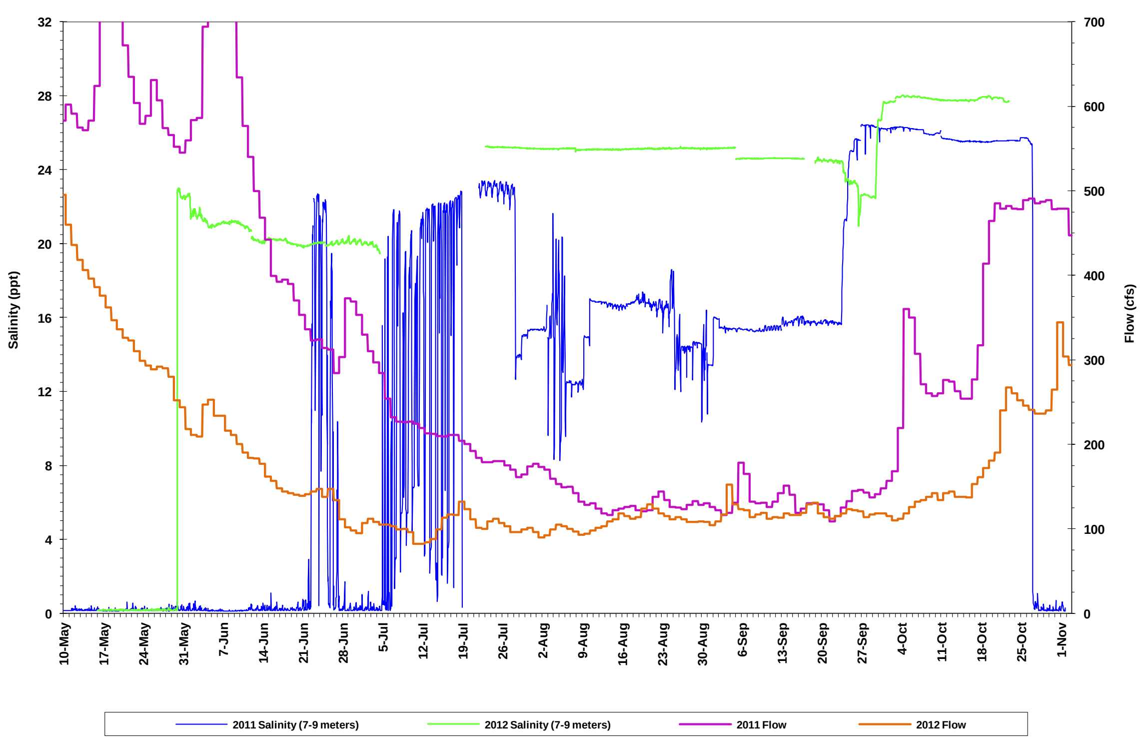

Figure 4.1.40. Comparison of salinity and flow for the years 2011 and 2012 in the Russian River estuary at the Heron Rookery Bottom Station.

Whereas in 2011, saltwater was not observed at the bottom of Heron Rookery until 22 June and did not become persistent at the site until mid-July.

Freshwater inflow rates may have also played a role in the difference in the amount of salinity migration between the years. Elevated spring flows dropped below 300 cfs in late May in 2012, whereas flows did not drop below 300 cfs until early July in 2011 (Figure 4.1.40).When the estuary is closed, or the river mouth is perched and the supply of cool tidal inflow is reduced, solar radiation heats the underlying saline layer. At night, the overlying surface freshwater layer restricts the release of this heat, which can result in higher water temperatures in the underlying saline layer than in the overlying freshwater layer. The saline bottom waters act as a solar collector and traps the heat, resulting in progressively higher relative water temperatures within the salt water lens (Smith, 1990). This effect was most pronounced in the lower and middle reaches of the estuary. Heating of the bottom and mid-depth layers of the water column was also observed in the upper reach to a lesser degree and was typically associated with the presence or migration of the salt wedge at the monitoring stations.

Through natural processes including reduced tidal circulation, dissolved oxygen concentrations can become depleted in the bottom saline layer and anoxic conditions can develop. This was observed in the lower half of the water column at the upper reach stations, in Willow Creek, and to a lesser degree at the mid-depth sondes in the lower and middle reaches.

During the 2012 grab sample effort, the draft EPA criteria for total phosphorus was exceeded a majority of time at all stations in the estuary and maximum backwater area. The total nitrogen draft criteria was exceeded several times at the three stations in the estuary, but was only exceeded once each at Casini Ranch and Monte Rio stations in the maximum backwater area.

Results for bacterial monitoring showed general compliance with the *E. coli* draft CDPH guideline, but several exceedances of the *Enterococcus* draft guideline. Exceedances of the *Enterococcus* draft guideline were observed under a variety of conditions including open tidal, muted tidal, and perched conditions, as well as a range of flows from 101 cfs to 253 cfs. The North Coast Regional Water Quality Control Board (NCRWQCB) is currently developing Total Daily Maximum Load (TMDL) allocations for pathogens (bacteria) in the Russian River and are in the process of collecting and analayzing data (NCRWQCB, 2013). The Regional Board is also focusing on *E. coli* and *Enterococcus* as indicator bacteria for the purposes of assessing water quality for beneficial uses, including contact recreation. To be consistent, the Water Agency will continue to focus on collecting grab samples for *E. coli* and *Enterococcus* for the 2013 montoring season. The Water Agency will also collect samples weekly in 2013 instead of once every two weeks.

Overall, monitoring in 2013 will continue to focus on the movement of the salt wedge within the estuary and will add a station above the Moscow Road Bridge in Duncans

Mills to track potential salinity migration above Freezeout Creek. Grab sampling in 2013 will be conducted weekly at the five stations sampled in 2012, and will continue to include additional focused sampling during barrier beach closure, lagoon outlet channel implementation, sandbar breach, or the removal of summer recreational dams to gain additional information on how they may affect nutrient, *Chlorophyll a*, or bacterial concentrations in the estuary.

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4.2 Invertebrate Monitoring and Salmonid Diet Analysis

The Biological Opinion requires the Water Agency to "monitor the effects of alternative water level management scenarios and resulting changes in depths and water quality (primarily salinity, dissolved oxygen concentration, temperature, and pH) on the productivity of invertebrates that would likely serve as the principal forage base of juvenile salmonids in the Russian River estuary. Specifically, SCWA will determine the temporal and spatial distribution, composition (species richness and diversity), and relative abundance of potential prey items for juvenile salmonids in the Russian River estuary, and evaluate invertebrate community response to changes in sandbar management strategies, inflow, estuarine water circulation patterns (stratification), and water quality. The monitoring of invertebrate productivity in the estuary will focus primarily on epibenthic and benthic marine and aquatic Arthropods within the classes Crustacea and Insecta, the primary invertebrate taxa that serve as prey for juvenile salmonids. The monitoring effort will involve systematic sampling and analysis of zooplankton, epibenthic, and benthic invertebrate species" (NMFS 2008, page 254).

The Water Agency entered into an agreement with the University of Washington, School of Aquatic and Fishery Sciences' Wetland Ecosystem Team (UW-WET) to conduct studies of the ecological response of the Russian River estuary to natural and alternative management actions associated with the opening and closure of the estuary mouth. This component of the Biological Opinion study is designed to evaluate how different natural and managed barrier beach conditions in the Russian River estuary affect juvenile salmon foraging and their potential prey resources over different temporal and spatial scales. Systematic sampling is intended to capture the natural ecological responses (prey composition and consumption rate) of juvenile salmon and availability of their prey resources (insect, benthic and epibenthic macroinvertebrates, zooplankton) under naturally variable, seasonal changes in water level, salinity, temperature and dissolved oxygen conditions. A second approach, event sampling, was originally proposed in 2009 to contrast juvenile salmonid foraging and prey availability changes over short-term estuary closure and re-opening events.

Methods

Sampling Sites

Sampling for fish diet and prey availability is designed to coincide with established Water Agency and other related sampling sites distributed in the lower, middle, and upper reaches of the Estuary during the Lagoon Management Period (May 15 to October 15). Salmonid diet samples are coincident with beach seining at nine sites (three in each reach) sampled for juvenile salmon by the Water Agency – (1) River Mouth; (2) Penny's Point; (3) Jenner Gulch; (4) Patty's Rock; (5) Bridgehaven; (6) Willow Creek; (7) Sheephouse Creek; (8) Heron Rookery; (9) Freezeout Bar; (10)

Moscow Bridge; (11) Casini Ranch; and, (12) Brown's Riffle. These locations also overlap with sites established by water quality measurements—dissolved oxygen, temperature and salinity (Figure 4.2.1; modified from Largier and Behrens [2010]). When possible, samples are selected for diet analysis from the overall beach seine collections from Jenner Gulch, Bridgehaven and Moscow Bridge to represent the lower, middle , and upper estuary reaches, respectively. Incidental steelhead diet samples also originate from Penny Point (lower), Willow Creek (middle), and Sheephouse Creek, Freezeout Bar, and Casini Ranch (upper) sites when there are not sufficient samples from the primary reach sites.

In addition, prey resource availability sampling occurs at four sites in the lower, middle, and upper reaches of the Russian River Estuary – River Mouth, Penny Point, Willow Creek, and Freezeout Bar (Figure 4.2.2). Each of the sites includes three, lateral transects across the Estuary (Figures 4.2.3a-d).

Juvenile Salmon Diet Composition

Systematic sampling of the diets of five or more ($n \geq 5$) juvenile steelhead ≥55 mm FL will be derived, when available, from the beach seine samples during the lagoon management period between May 15 and October 15. If resources are available and sample sizes are less than 5 individual fish (n=<5) during systematic sampling, event sampling around scheduled beach management at the barrier beach shall be coordinated with Water Agency fisheries monitoring and physical measurements of estuarine response.

To the degree possible, all fish designated for diet analysis will be gastric lavaged and released according to the University of Washington animal care protocols. Stomach lavage follows Foster (1977) and Light et al (1983). Diet contents are preserved in 10% Formalin for later laboratory processing. As per Water Agency fisheries protocols (see Beach Seining section below), fork lengths and weights are taken from each fish. Each fish is scanned for a passive integrated transponder (PIT) tag and tagged if no previous PIT tag was detected.

Prey Resource Availability

Benthic infauna and epibenthos prey resource sampling is conducted once per month in the Lagoon Management Period during open, tidal (baseline) conditions. If barrier beach closure or outlet channel implementation results in a closure, epibenthos and benthic infauna are sampled at 7 and 14 days after closure. Following an extended closure of 14 days or more, prey resource availability sampling will continue beginning at day 14 and every three weeks after and include benthic infauna, epibenthos, and zooplankton resource availability sampling as described below.

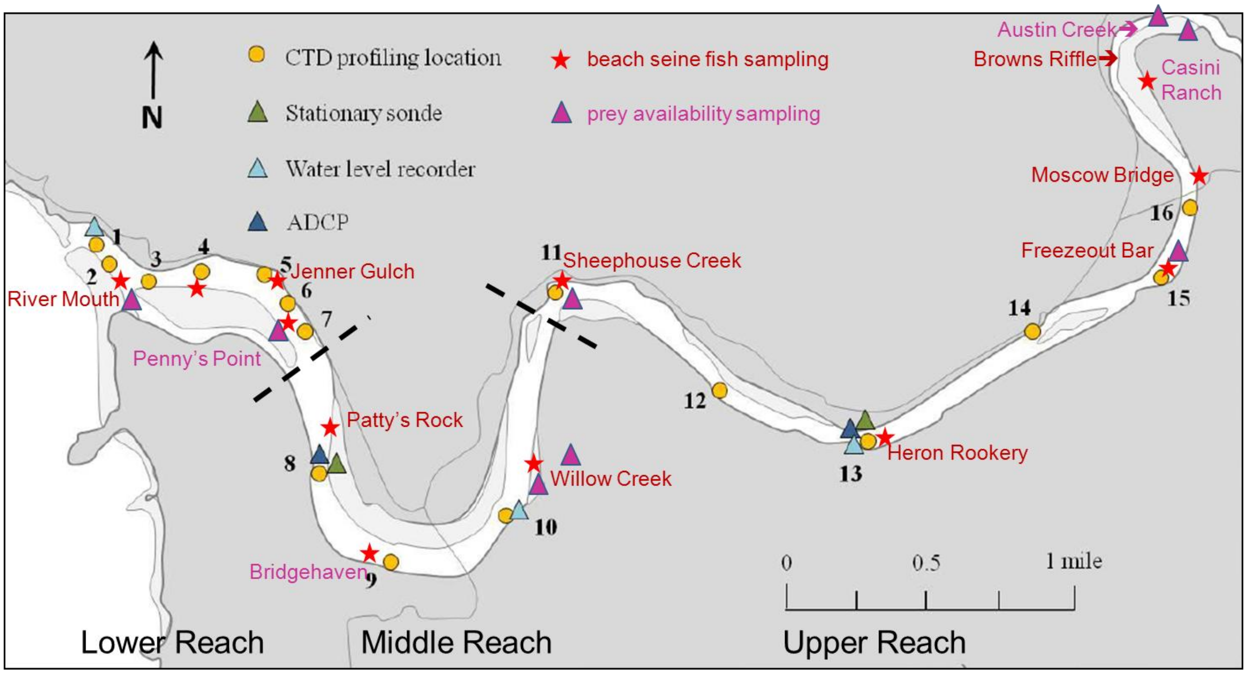


Figure 4.2.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resource availability (benthic infauna, epibenthos, zooplankton) in three reaches of the Russian River Estuary.

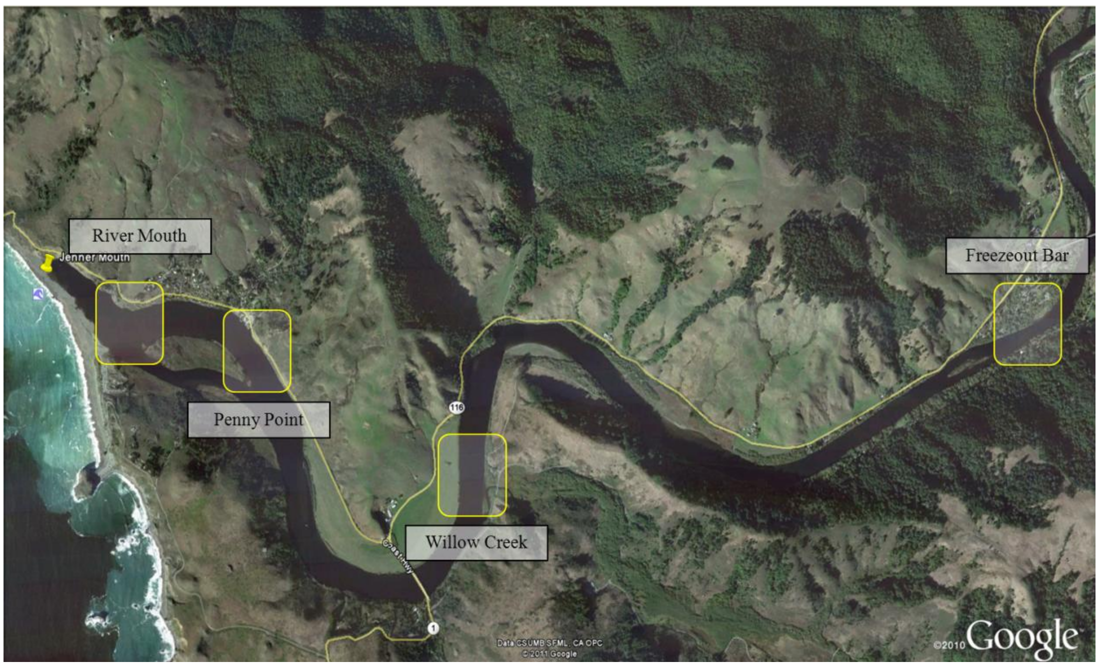


Figure 4.2.2. Distribution of juvenile salmonid prey resource availability sampling sites in the Russian River Estuary.

(a) Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River Estuary.

(b). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Penny Point site in the Russian River Estuary.

Figure 4.2.3a-b. Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River Estuary: (a) River Mouth; (b) Penny Point; (c) Willow Creek; and (d) Freezeout Bar.

(c). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Willow Creek site in the Russian River Estuary.

(d). Distribution of juvenile salmonid prey availability sampling transects and techniques at the Freezeout Bar site in the Russian River Estuary.

Figure 4.2.4c-d. Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River Estuary: (a) River Mouth; (b) Penny Point; (c) Willow Creek; and (d) Freezeout Bar.

Benthic Infauna—Replicate core samples (0.0024-m^2 PVC core inserted 10 cm in to the sediment) are taken at each transect of each site. The location of each core sample is consistent with each sled pull and epibenthic net pull, but no core samples are taken in between transects. This sample is repeated four times per transect (twelve times per site). Additional samples would be added along the transect with increasing water level (inundation of the shoreline) during closure or outlet channel implementation. The sediment cores are preserved in 10% buffered Formalin for laboratory analysis.

Epibenthos—Epibenthic organisms at the sediment-water interface are sampled with two methods: (1) epibenthic net; and (2) epibenthic sled. The epibenthic net is a 0.5-m x 0.25-m rectangular net, equipped with 106-µm Nitex mesh, that is designed to ride along the surface of the estuary bottom. It is deployed 10 m perpendicular to shore and then pulled along the bottom back to shore by an individual onshore. This is replicated five times per site (once at each transect and then once between Transects 1 and 2 and also between Transects 2 and 3). The epibenthic sled is equipped with a 0.125-m^2 opening, 1-m long 500-µm Nitex mesh net towed behind the boat against the current. The sled is dropped off of the bow of the boat and allowed to sink to the bottom. Once the boat has finished towing the sled (in reverse) 10 m against the current, it will be retrieved back onto the boat. This is replicated five times per site (once at each transect and then once between Transects 1 and 2 and also between Transects 2 and 3). The sled is used to obtain three samples per transect (nine per site under open conditions). Additional samples would be added along the transect with increasing water level (inundation of the shoreline) during closure or outlet channel implementation. Captured organisms are preserved in 10% buffered Formalin for laboratory analysis.

Zooplankton—Zooplankton are sampled at the same location as water quality (the deepest available depth per site) using a 0.33-m ring net, 73-µm Nitex mesh and cod end cup. Replicated (n=3) vertical water column hauls are made by lowering the zooplankton net until the top ring of the net is just above the benthos and then pulled by hand vertically to the surface to obtain a sample of the entire water column. This sample set is repeated three times per site. Captured organisms are preserved in 10% buffered Formalin for laboratory analysis.

Sampling Completed

Monthly sampling was completed from May through October 2012. Table 4.2.1 provides a summary of sampling completed. Invertebrate sampling was completed under a range of open and closed river mouth conditions. Table 4.2.2 provides a summary of river mouth conditions and water surface elevation ranges in the Estuary.

Table 4.2.1. 2012 Invertebrate Sampling in the Russian River Estuary.

Station	Date	Number of Samples by Type				
		Benthic Core	Sled-Channel	Epi-Benthic net to shore	Zooplankton Haul	Fall-Out Trap
River Mouth	29-May	12	9	5	3	5
	25-Jun	12	9	5	3	5
	23-Jul	12	9	5	3	5
	20-Aug	12	9	5	3	5
	10-Sep	12	9	5	3	5
	8-Oct	12	9	5	3	5
Penny Point	29-May	12	9	5	3	5
	25-Jun	12	9	5	3	5
	23-Jul	12	9	5	3	5
	20-Aug	12	9	5	3	5
	10-Sep	12	9	5	3	5
	8-Oct	12	9	5	3	5
Willow Creek	29-May	12	9	5	3	5
	25-Jun	12	9	5	3	5
	23-Jul	12	9	5	3	5
	20-Aug	12	9	5	3	5
	10-Sep	12	9	5	3	5
	8-Oct	12	9	5	3	5
Freezeout	29-May	12	9	5	3	5
	25-Jun	12	9	5	3	5
	23-Jul	12	9	5	3	5
	20-Aug	12	9	5	3	5
	10-Sep	12	9	5	3	5
	8-Oct	12	9	5	3	5
Total # of Samples		288	216	120	72	120

Table 4.2.2. Summary of Russian River Estuary river mouth conditions and water surface elevations during 2012 invertebrate sampling events.

Sample Date	Mouth Condition	Water Level (ft) (10am-2pm)
29-May	Muted Tides (leading to closure)	1.1 - 0.6
25-Jun	Muted Tides (after opening)	2.5 - 2.4
23-Jul	Muted Tides (after opening)	1.9 - 2.0
20-Aug	OPEN	0 - 2.3
10-Sep	OPEN	1.2 - 0.6
8-Oct	CLOSED (first day of closure)	2.1

Sample Processing and Analyses

Stomach contents from juvenile salmon are identified to the species level if possible under a dissecting microscope. Invertebrates found in the diets of steelhead and collected in the prey resource samples are identified to species level, except for insects which are indentified to family level. Any invertebrate collected during prey sampling and not found to be part of the steelhead diet is identified to order or family level. Each of the identified prey taxa are counted (for numerical composition) and weighed (for gravimetric [biomass] composition) and the frequency of occurrence. The state of total stomach content biomass is normalized by individual fish weight to provide an additional index of relative consumption rate (“instantaneous” ration).

In addition to individual metrics of diet composition, the Index of Relative Importance (IRI; Pinkas *et al.* 1971) is also calculated, wherein %Total IRI for each discrete prey taxa takes into account the proportion that prey taxa constitutes of the total number and biomass of prey and the frequency of occurrence of that taxa among in the total number of fish stomach samples:

$$IRI_i = FO_i * [NC_i + GC_i]$$

where NC is the percent numerical composition, GC is the percent gravimetric (biomass) contribution, FO is the percent frequency of occurrence for each of the prey taxa, and *i* is the prey taxa; results are expressed as a percentage of the total IRI for all prey items. We also interpret diet composition using just GC_i in order to better represent the bioenergetic contribution of prominent (from a FO_i standpoint) prey.

Multivariate analyses are also utilized to organize fish diet sample compositions and prey availability samples into statistically distinct categories. All statistical analyses are performed using the PRIMER v6.0 multivariate statistics analysis package (Clarke and Gorley 2006). These analytical tools, and the PRIMER package in particular, are used extensively in applied ecology and other scientific inquiries where the degree of similarity in organization of multivariate data (e.g., species, ecosystem attributes) is of interest.

Results

Samples collected during the 2012 Lagoon Management Period are continuing to be analyzed by University of Washington. An addendum to this report will be issued upon completion of the laboratory analysis to provide results and conclusions of the 2012 sampling efforts.

References

Foster, J. R. 1077. Pulsed gastric lavage: an efficient method of removing the stomach contents of liver fish. The Prog. Fish. Cult. 39:166-169.

Largier, J., and D. Behrens. 2010. Hydrography of the Russian River Estuary Summer-Fall 2009, with special attention on a five-week closure event. Unpubl. Rep. to

Sonoma County Water Agency, Bodega Marine Laboratory, University of California, Davis. 72 pp.

Light, R. W., P. H. Alder and D. E. Arnold. 1983. Evaluation of gastric lavage for stomach analyses. N. Am. J. Fish Mgmt. 3:81-85.

4.3 Downstream Migrant Trapping

The Reasonable and Prudent Alternative (RPA) in the Russian River Biological Opinion compels the Water Agency to provide information about the timing of downstream movements of juvenile steelhead, their relative abundance and the size/age structure of the population as related to the implementation of an adaptive management approach to promote formation of a perched freshwater lagoon. The sampling design implemented by the Water Agency and described in this section specifically targets the detection and capture of anadromous salmonid young-of-the-year (YOY, age-0) and parr ($\geq$age-1) (collectively referred to as juveniles) as well as smolts. In order to help accomplish the objectives listed above, the Water Agency undertook fish capture and PIT-tagging activities at selected sites upstream of the estuary (Austin, Dutch Bill, Mark West Creeks and the mainstem Russian River at Mirabel, Figure 4.3. 1.) as well as the operation of stationary PIT antenna arrays near the mouth of Austin Creek (riverkm 0.5) and at the upstream end of the estuary in Duncans Mills (riverkm 10.46). Implementation of the monitoring activities described here are the result of a continually-evolving process of evaluating and improving on past monitoring approaches. Descriptions and data from other monitoring activities conducted in the estuary (e.g., water quality monitoring, beach seining) as well as fish trapping operations in Dry Creek and Chinook data from the Mirabel downstream migrant traps are presented elsewhere in this report.

Methods

In 2012 we again relied on downstream migrant traps and stationary PIT antenna arrays at lower-basin trap sites to address the objectives in the RPA. Similar to 2010 and 2011, fish were physically captured at downstream migrant traps (rotary screw trap, funnel trap or pipe trap), sampled for biological data and released. PIT tags were applied to the majority of age-0 steelhead captured at these trap sites and fish were subject to detection at downstream PIT antenna arrays and on an underwater video camera if they moved downstream into the estuary. In the sections that follow, we describe the sampling methods and analyses conducted for data collected at each site.

Estuary PIT antenna system

On May 14, we constructed a two wing walls consisting of several 50 foot long by either 4 or 8 foot tall net panels. The wing walls were oriented in such a way as to constrict downstream-moving fish through a remote detection system consisting of a swim-through PIT antenna and underwater video camera/DVR inside a video viewing chamber. The remote detection system was situated at the apex of the wing walls so that downstream-moving individuals could be digitally-recorded and detected by the PIT reader if they were PIT-tagged (tagged at upstream locations) as they are guided through the apex. The site was slightly upstream of the 2009-2011 fyke net site on a low gradient riffle between the Cassini Ranch campground and the Moscow Road Bridge at

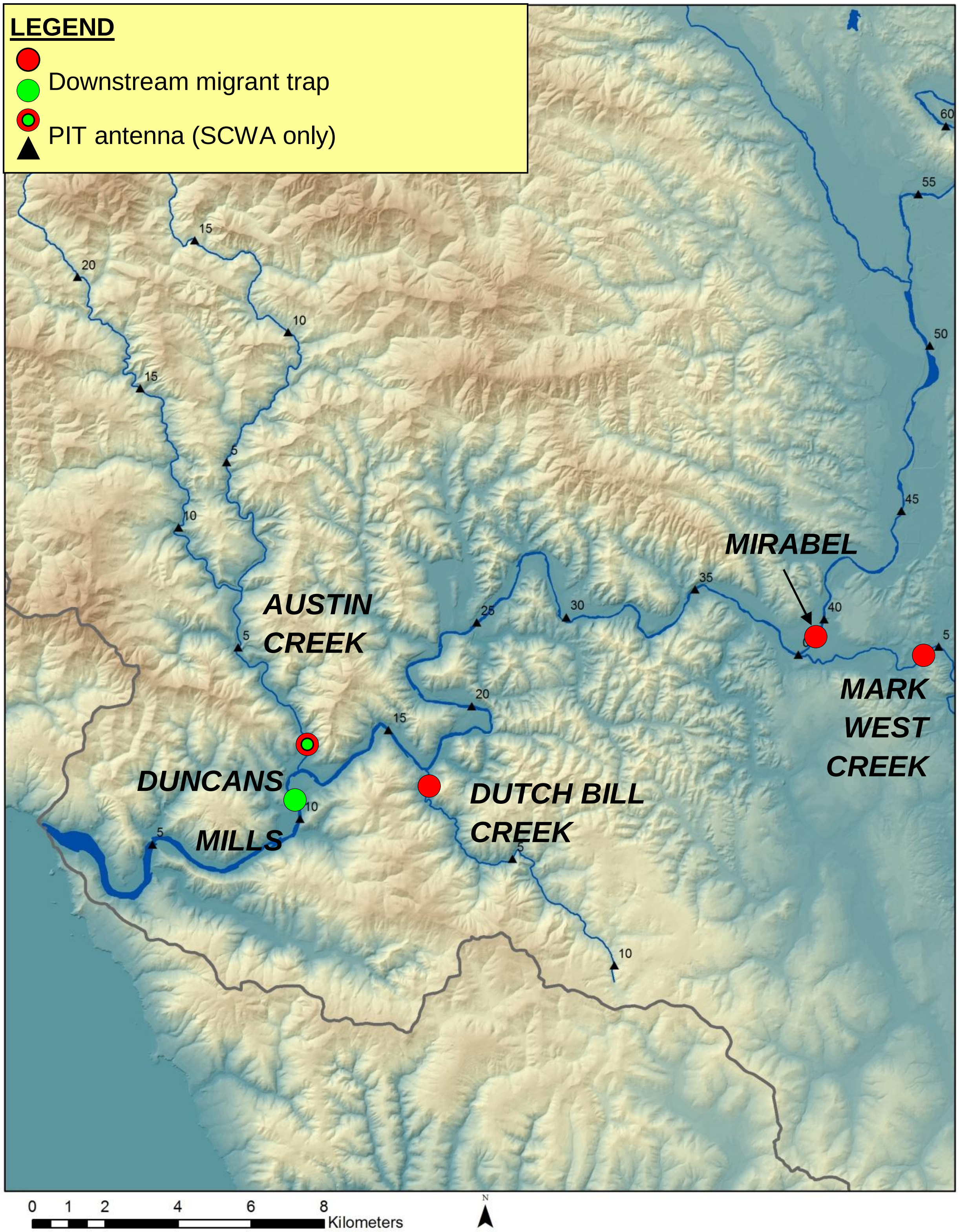


Figure 4.3. 1. Map of downstream migrant detection sites in the lower Russian River, 2012. Numbered dots along stream courses represent distance (km) from the mouth of each stream.

river km 10.46. With minor exceptions, this was the same basic approach used for detecting juvenile fish movement into the estuary as that employed in 2010 and 2011 and described in Manning and Martini-Lamb (2012). Date and time were recorded for all PIT-tagged fish that were detected and date, time and direction of movement (upstream or downstream) were noted for each fish observed passing through the viewing chamber. In order to estimate fish lengths from the video footage, vertical lines spaced 10 mm and 50 mm apart were drawn on the viewing chamber so that lengths could be estimated from the line spacing. The video camera and PIT antenna were operated 24 hours per day during the late spring through mid-summer except for periods described below.

Although the first PIT antenna was installed on May 14, due to camera and DVR malfunction we did not begin to record video footage until June 13. Video was recorded continuously until removal of the camera and wing walls on July 26. Between June 8 and June 19, we installed five antennas in addition to the original antenna for a total of six antennas (Figure 4.3. 2). The newly-installed antennas had a “flat-plate” orientation (designed to lay flat on the stream bottom) as opposed to the “swim-through” orientation (designed to stand upright in the water column) of the antenna installed on May 14. The five newly- installed antennas remained in place for the remainder of 2012.

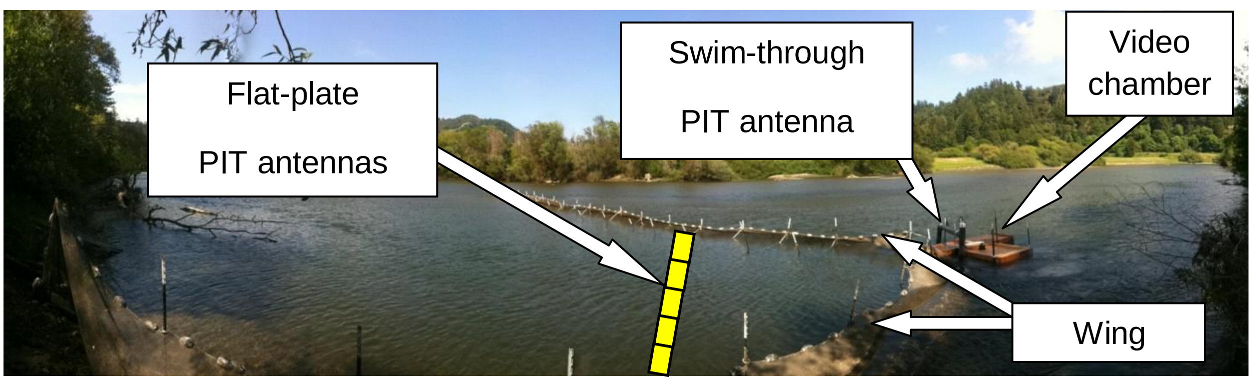


Figure 4.3. 2. Photograph of wing walls, video box and PIT antennas installed on May 14.

Lower River fish trapping and PIT tagging

As a result of consultation with NMFS and CDFW, the Water Agency identified three lower River tributaries (Mark West Creek, Dutch Bill Creek and Austin Creek) in which to operate fish traps as a way to supplement data collected from the Duncans Mills fish sampling station and during sampling by beach seining throughout the estuary (Figure 4.3. 1.). In addition to PIT-tagging juvenile steelhead at these sites, juvenile steelhead were also captured and PIT-tagged at the Water Agency’s downstream migrant trapping site on the mainstem at Mirabel; this resulted in a total of four possible sources of PIT-tagged fish that we could monitor if and when they entered the estuary (Figure 4.3.3).

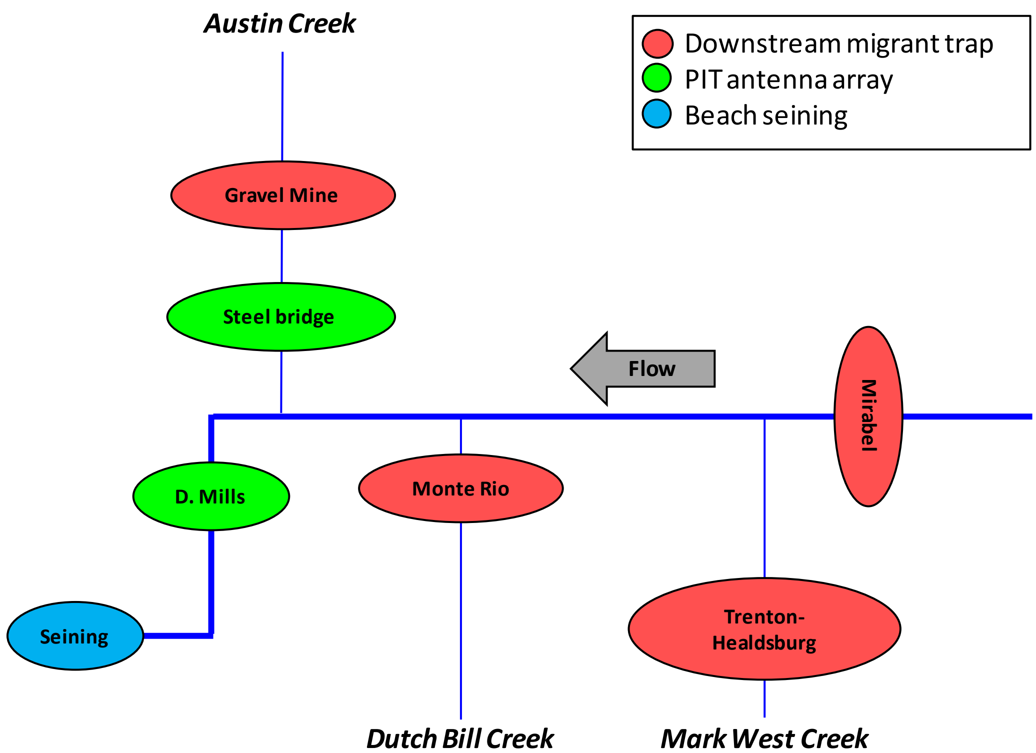


Figure 4.3.3. The relationship of lower-river downstream migrant traps (Mirabel, Mark West Creek, Dutch Bill Creek and Austin Creek) to estuary monitoring sites (Duncans Mills and beach seining).

The Water Agency operated three types of downstream migrant traps in 2012: rotary screw trap, funnel traps and pipe traps depending on the stream, water depth, and velocity (Figure 4.3.4). Two rotary screw traps were operated at the Mirabel dam site. Fish traps were checked daily by Water Agency staff during the trapping season (April through July). Captured fish were enumerated and identified to species and life stage at all traps. All PIT-tagged fish were measured for fork length (±1 mm) and weighed (±0.1 g). Additionally, a subset of all non-PIT-tagged individuals were measured and weighed each day. PIT tags were implanted in a portion of the total capture of steelhead YOY and parr ≥60 mm in fork length. Growth data collected from fish originally PIT-tagged in lower river traps then recaptured during beach seining surveys is covered in the *Synthesis* chapter of this report.

Austin Creek: Rotary screw trap (fished 4/16-5/22) switched to funnel trap (fished 5/22-7/2).

Dutch Bill Creek: Funnel trap (fished 4/4-5/14) switched to pipe trap (5/15-6/14).

Mark West Creek: Rotary screw trap (fished 5/4-6/6) switched to pipe trap (fished 6/6-7/3).

Figure 4.3.4. Photographs of downstream migrant traps operated by the Water Agency (Austin, Dutch Bill and Mark West Creeks). See *Mirabel Downstream Migrant Trapping* in Section 8.3 of this report for details regarding operation of the Mirabel traps.

Austin Creek

A five foot rotary screw trap was installed on Austin Creek on April 16. To increase trap efficiency, wood-frame/plastic-mesh weir panels and a metal-mesh ramp were installed to direct fish and flow into the screw trap. By late May, the rotary screw trap was not fishing effectively due to low stream velocities; therefore, on May 22 we replaced the screw trap with a funnel trap that fished through the end of the trapping season on July 2. The funnel trap consisted of wood-frame/plastic-mesh weir panels, a funnel net and a wooden live box; it was located on a riffle approximately 200 m downstream of the rotary screw trap site. Trapping continued until surface flow in Austin Creek was no longer contiguous and daily catches of steelhead dropped rapidly (Table 4.3.1).

Table 4.3.1. Installation and removal dates, and total number of days fished for lower river monitoring sites operated by the Water Agency.

Monitoring site (gear type)	Installation date	Removal date	Number of days fished
Duncans Mills (video)	6/13	7/26	43
Duncans Mills (PIT antenna array)[1]	5/14	continuous (not removed)	231
Austin Creek (DSMT)	4/16	7/2	76
Dutch Bill Creek (DSMT)	4/5	6/14	56
Mark West Creek (DSMT)	5/4	7/2	58
Mirabel (DSMT)	4/25	7/3	67

[1]See text for details on changes to PIT antenna array throughout the season.

A portion of the steelhead PIT-tagged at the Austin Creek fish trap were released upstream of the trap in order to estimate trap efficiency. Trap efficiencies are commonly calculated by releasing fish that are highly motivated to move downstream (e.g., smolts) upstream of a fish trap (Bjorkstedt 2005). Because not all juvenile steelhead are necessarily motivated to move downstream, this is not necessarily a suitable life stage to use for estimating trap efficiency. Therefore, although failure to recapture a juvenile steelhead released upstream of the trap may be due to trap inefficiency (e.g., fish passage but failure to capture), it may also be due to some fish remaining upstream of the trap where they may take up residence or die.

To help distinguish between failure to capture due to trap inefficiency vs. failure to re-emigrate, a dual antenna PIT antenna array was installed on April 17, approximately 0.2 km downstream of the rotary screw trap in order to detect PIT-tagged steelhead. The PIT antenna array was located approximately 0.5 km from the mouth of Austin Creek at the upstream extent of the area that can be inundated by the Russian River during closure of the barrier beach; therefore, we assumed that once fish passed the antenna array they had effectively entered the estuary/lagoon.

To gain estimates of the number of fish emigrating from Austin Creek, trap efficiencies were calculated by using the total number of PIT-tagged steelhead that were released upstream of the trap, recaptured in the trap and detected later on the downstream antennas. Because the antenna array consisted of two antennas, we could estimate antenna efficiency using a similar approach (Figure 4.3.5; Zydlewski et al. 2006).

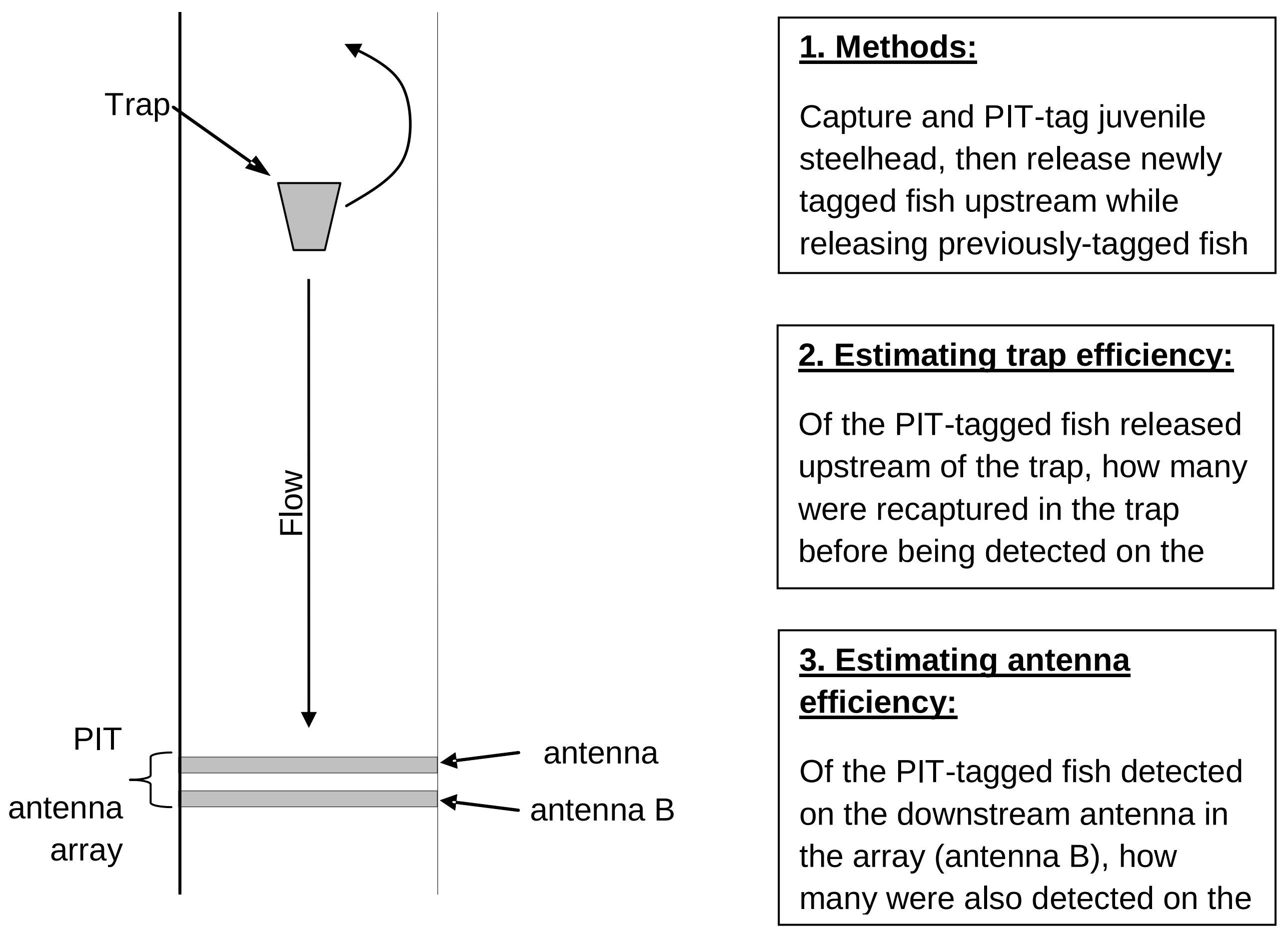


Figure 4.3.5. Diagram illustrating the relative location of the downstream migrant trap and PIT antenna array operated on Austin Creek and outline of how trap and antenna efficiencies were estimated.

Dutch Bill Creek

A funnel trap was installed on Dutch Bill Creek adjacent to the park in downtown Monte Rio (approximately 0.3 km upstream of the creek mouth) on April 4. On May 15, the trap was converted to a pipe trap because of low water velocities. The trap was fished until the completion of trapping operations on June 14 when stream flow in lower Dutch Bill Creek became disconnected (Table 4.3.1).

Mark West Creek

A five foot rotary screw trap was installed on Mark West Creek approximately 4.8 km upstream of the mouth on May 4. On May 17 a funnel net was also installed and fished simultaneously with the screw trap until May 24. On June 7 the rotary screw trap was removed and replaced with a pipe trap because of low water velocities. The pipe trap was removed and all trapping operations were suspended on July 3 when fish captures dropped off rapidly (Table 4.3.1).

Mainstem Russian River at Mirabel

Two rotary screw traps (one 5 foot and one 8 foot) adjacent to one another were operated on the mainstem Russian River immediately downstream of the Water Agency's inflatable dam site at Mirabel (approximately 38.7 km upstream of the river mouth) from April 25 to July 3 (Table 4.3.1). The purpose of this trap was to fulfill a broader set of objectives in the Russian River Biological Opinion than what is described in the current section of this report. However, one of the objectives was to provide a source of PIT-tagged steelhead juveniles that may enter the estuary and be detected during downstream monitoring efforts. Therefore, we report the number of steelhead that we applied PIT tags to at the Mirabel downstream migrant trapping site in the *Results* section. Other methods and results related to the Mirabel fish trapping effort in 2012 are detailed in the *Mirabel Downstream Migrant Trapping* section(Section 8.2) of this report.

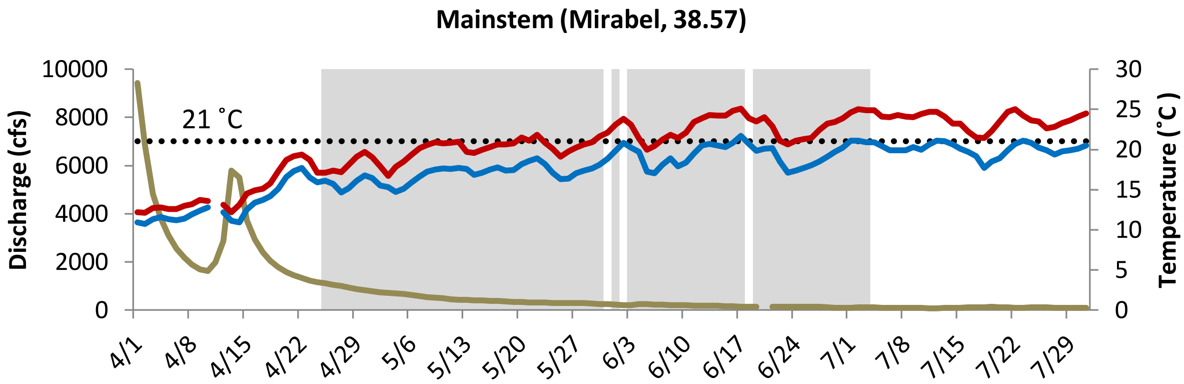
Results

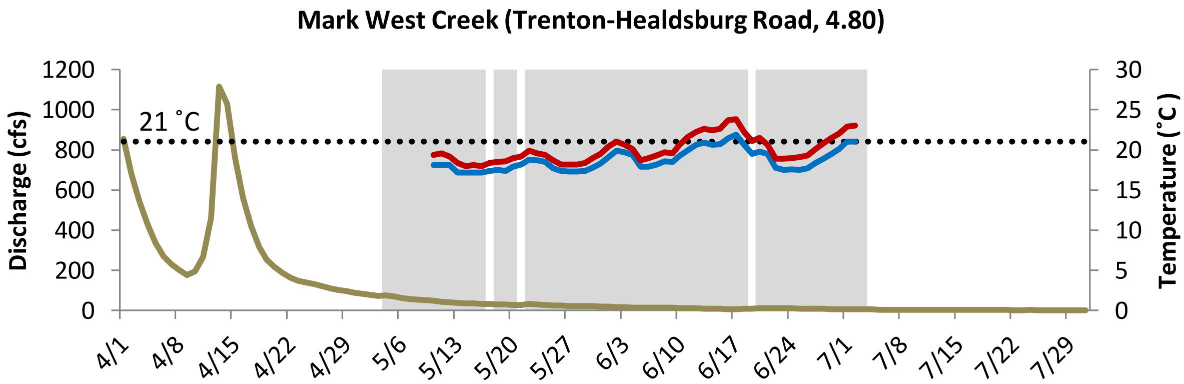
Stream flow largely dictates when downstream migrant traps can be installed (Figure 4.3.6). Our sampling period most likely encompassed a high portion of the juvenile steelhead movement period but we probably missed a substantial portion of the steelhead smolt migration period.

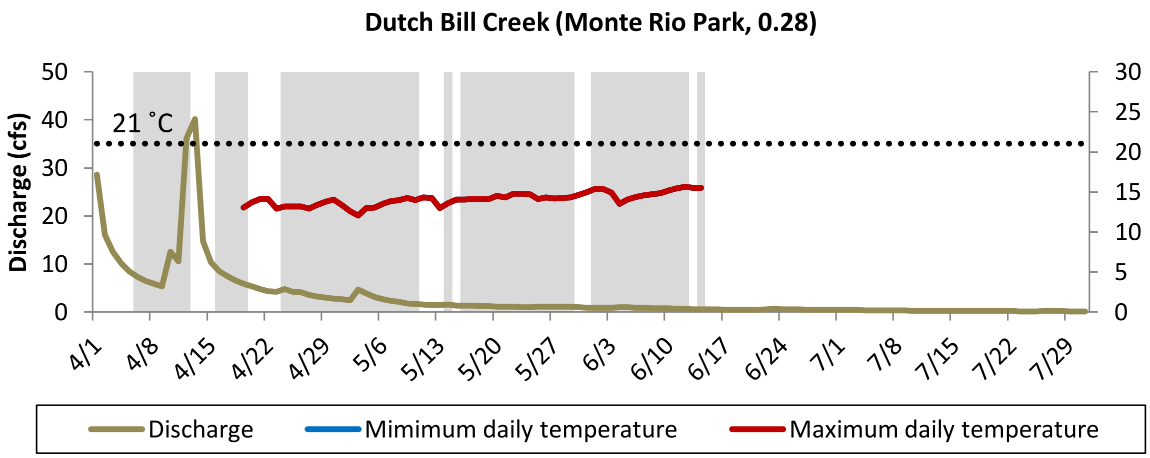
Estuary video camera and PIT antenna systems

Steelhead

A total of only 58 individual salmonids were counted on the underwater video system at Duncans Mills in 2012 as compared to 1,706 in 2010 and 1,096 salmonids in 2011. Of those 58 individuals, only 33 could be positively identified as juvenile steelhead. We believe that higher water velocity through the viewing chamber (resulting in fewer frames per fish) and ponding upstream of the net from the accumulation of filamentous algae on the wing walls are the main reason for the low numbers of fish observed in 2012; however, differences in timing of video operation undoubtedly were also a factor (Table 4.3.2). After the end of the 2012 downstream migrant season, the Water Agency consulted with NMFS and, based on data from 2009-2012 at Duncans Mills, came to the conclusion that annual operation of the fyke net and video monitoring system in the estuary is infeasible and therefore should be discontinued.







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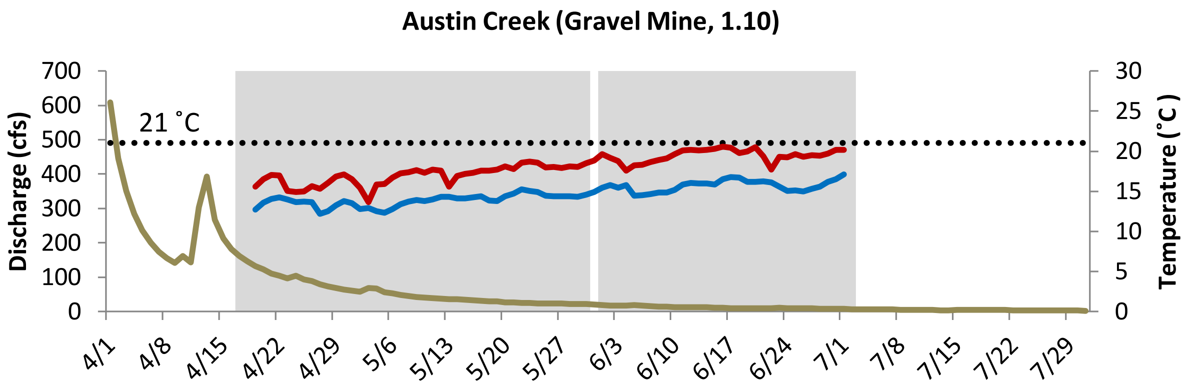


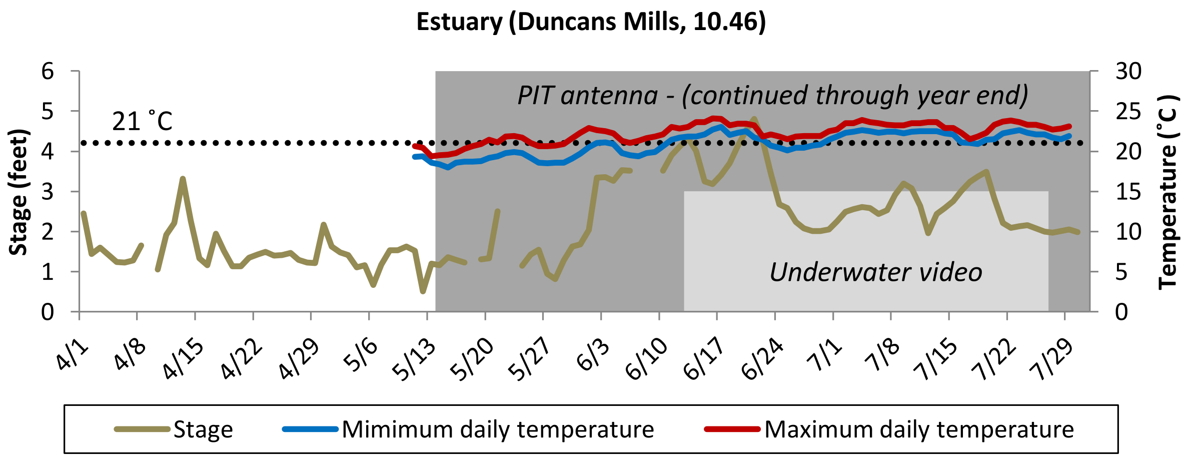


Figure 4.3.6. Environmental conditions at downstream migrant detection sites from April 1 to July 31. Gray shading indicates the proportion of each day that each facility was operated and discharge data are from the USGS gage at Haceinda (mainstem, 11467000), the USGS gage at Trenton-Healdsburg Road (Mark West Creek, 11466800) the CEMAR gage near Grub Creek (Dutch Bill Creek) and the USGS gauge at Cazadero (Austin Creek, 11467200). Stage data for the estuary are from the Jenner gage. Temperature data are from the data loggers operated by the Water Agency at each monitoring site. The 21°C line represents the temperature limit where the Water Agency is only permited to identiy and count captured fish. Above 21°C fish can not be measured, weighed or PIT tagged.

Table 4.3.2. Dates of operation and number of steelhead observed on the estuary fyke net video system, 2012.

Year	Start date	End date	Days Operated	Number of juvenile steelhead observed
2010	5/27	8/1	61	484
2011	4/28	7/20	71	98
2012	6/13	7/26	44	33

Trapping operations in Austin, Dutch Bill and Mark West Creeks, allowed us to PIT tag more steelhead in 2012 (total=2,000) than in prior years (Table 4.3.3) and, as in past years, steelhead were most frequently encountered in Austin Creek. Over the course of the season, 3,666 steelhead were captured of which 2,573 were YOY, 1,093 were parr ($\geq$age-1) and 170 were smolts (Figure 4.3.7). We applied PIT tags to 1,639 individuals; based on their size, 1,518 of this total were estimated to be YOY. In total, 1,356 PIT-tagged steelhead were released upstream of the trap (**Error! Reference source not found.**). Of those 1,356, we have high certainty that at least 486 moved downstream because they were detected on the downstream PIT antenna array. Of the individuals detected on the downstream PIT antenna array, 196 were first recaptured in the trap resulting in an estimated trap efficiency of 40.3% (196/486). Based on this trap efficiency, we estimate that the population size of YOY steelhead moving past (or in the vicinity of) the trap was approximately 5,804. Of the 129 individuals detected at Duncans Mills, 85 were also detected on one or both of the Austin Creek antennas resulting in an estimated site efficiency of 65.9% (85/129). This resulted in an estimate of 50% (759/1,518) of the PIT-tagged population that moved downstream. By inference, we assume that a similar proportion of the entire YOY steelhead population ($\geq$60 mm) estimated at the trap site also moved downstream. Therefore, we estimate that approximately 2,901 steelhead YOY from Austin Creek emigrated into the tidal portion of the estuary in 2012. The Austin Creek trap catch and population estimate has varied over the three years these estimates have been possible (2010-12), but the estimated emigration rate (proportion of PIT-tagged YOY that emigrated) has remained fairly similar among years (Figure 4.3.7).

In 2012, 983, 95 and 21 steelhead juveniles were caught at Mirabel, Mark West and Dutch Bill Creeks, respectively (Figure 4.3.7). During 2012, PIT tags were applied to 312, 43 and 6 juvenile steelhead at Mirabel, Green Valley and Dutch Bill Creeks, respectively (Table 4.3.3). Fork lengths of fish caught at these traps show at least 3

Table 4.3.3. Number of PIT-tagged steelhead juveniles tagged at downstream migrant monitoring locations in the lower river in 2009-2012.

Site	2009	2010	2011	2012
Mainstem (Mirabel)	17	96	100	312
Mark West Creek	not fished	not fished	not fished	43
Green Valley Creek	no PIT tagging	17	0	not fished
Dutch Bill Creek	not fished	46	23	6
Austin Creek	not fished	997	500	1,639
Estuary fyke net	4	no trapping	no trapping	no trapping
Total	**21**	**1,156**	**623**	**2,000**

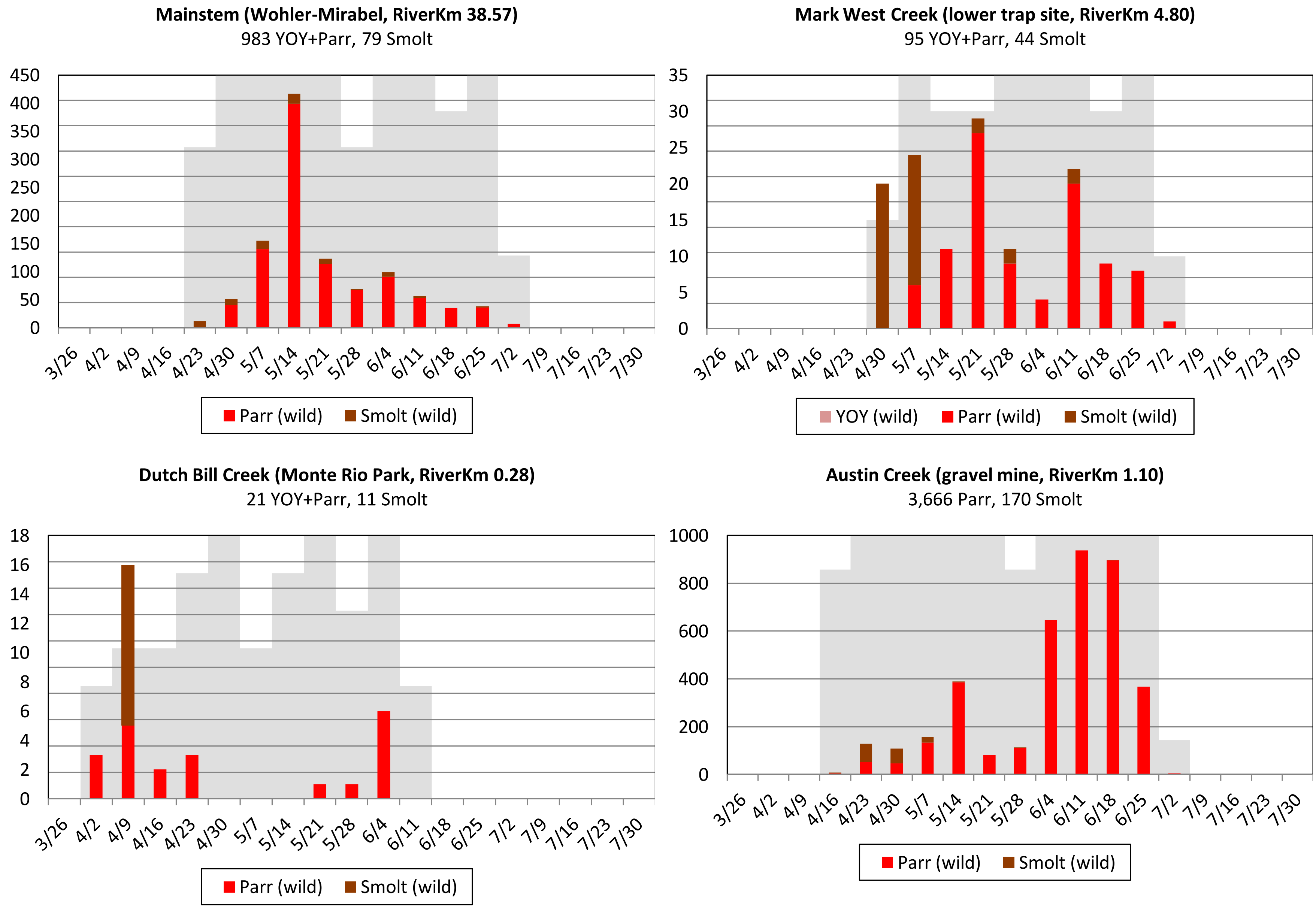


Figure 4.3.7. Weekly capture of steelhead by life stage at lower river downstream migrant trapping sites, 2012. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.

Table 4.3.4. PIT tag and trap capture metrics and values for YOY steelhead in Austin Creek. Note that 2010 numbers differ from Martin-Lamb and Manning (2011) because they have been adjusted to only include YOY.

Metric	2010	2011	2012
Number PIT-tagged YOY released upstream of trap	765	324	1,356
Number PIT-tagged YOY released downstream of trap	195	2	162
Number PIT-tagged YOY detected on antenna array that were tagged in Austin Creek	547	131	574
Number PIT-tagged YOY released upstream & detected on antenna array	389	131	486
Number released upstream & recaptured in trap & detected on antenna	47	8	196
ESTIMATED TRAP EFFICIENCY	**12.1%**	**6.1%**	**40.3%**
Number YOY+parr detected on both antennas in array	241	93	85
Number YOY+parr detected on downstream antenna only	288	178	129
ESTIMATED ANTENNA EFFICIENCY	**83.6%**	**52.2%**	**65.9%**[1]
Number YOY captured and PIT-tagged	960	324	1,518
Total number of YOY captured (≥60 mm only)	2,617	453	2,341
ESTIMATED NUMBER OF PIT-TAGGED YOY EMIGRANTS (≥60 mm only)	**632**	**251**	**759**
ESTIMATED PROPORTION OF PIT-TAGGED YOY THAT EMIGRATED (≥60 mm only)	**65.8%**	**77.5%**	**50%**
ESTIMATED POPULATION SIZE OF YOY AT TRAP	**21,628**	**7,426**	**5,804**
ESTIMATED NUMBER OF YOY IN POPULATION THAT EMIGRATED	**14,231**	**5,755**	**2,901**

Efficiency is based on detections of PIT-tagged fish at Duncans Mills.

year classes with steelhead YOY present at each of the trapping locations (Figure 4.3.8). As in other years,we assume that the few steelhead smolts captured at any of the trap sites was likely due to a large portion of the smolt outmigration occurring before trap installation and the generally low trap efficiencies for steelhead smolts that is well-documented in the Russian River and elsewhere. The season total catches of steelhead at Mirabel has show an increasing trend since 2009 (Figure 4.3.9), with no apparent similar trend in Dutch Bill and Austin Creek trap catches (Figure 4.3.10 and Figure 4.3.12).

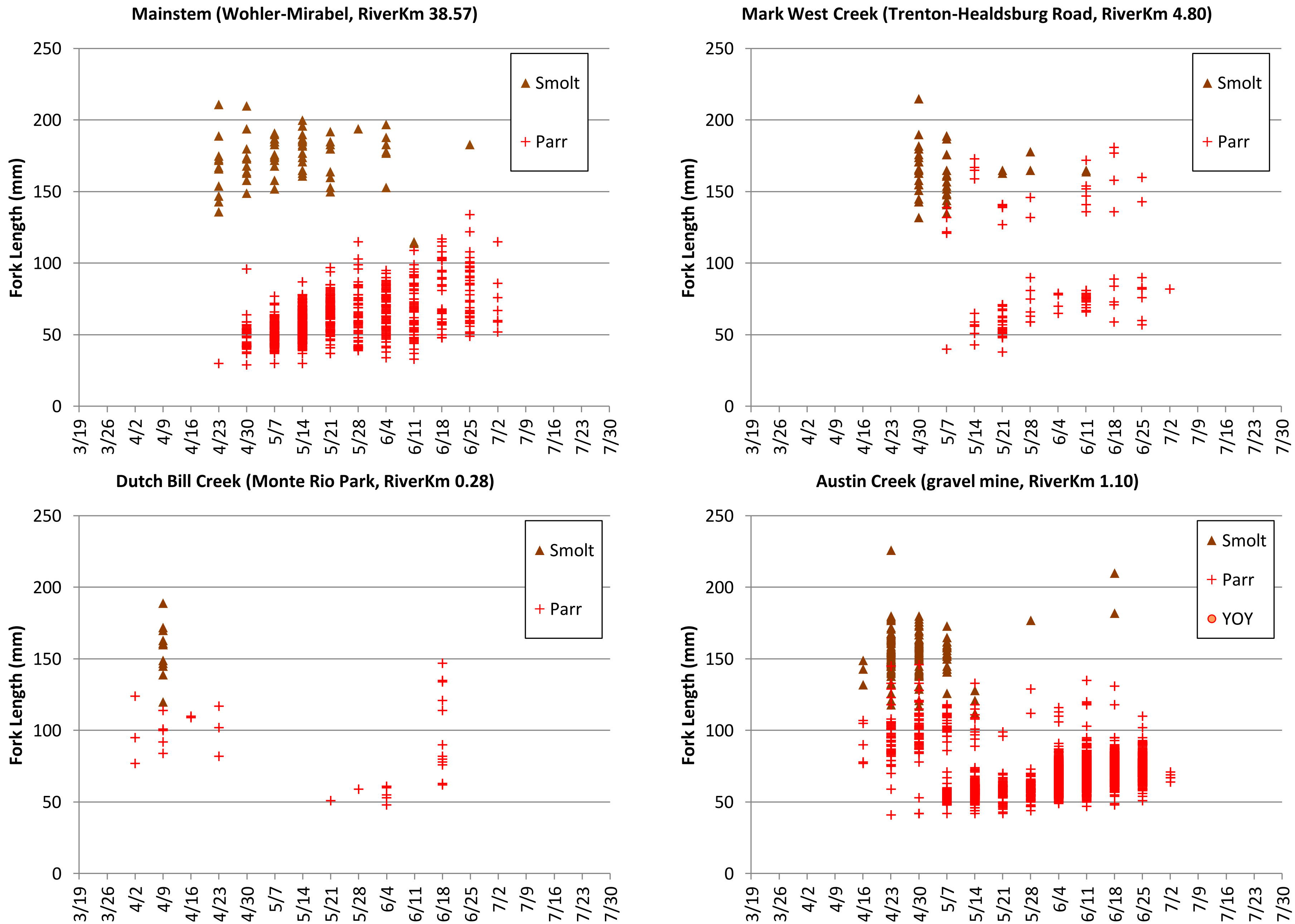
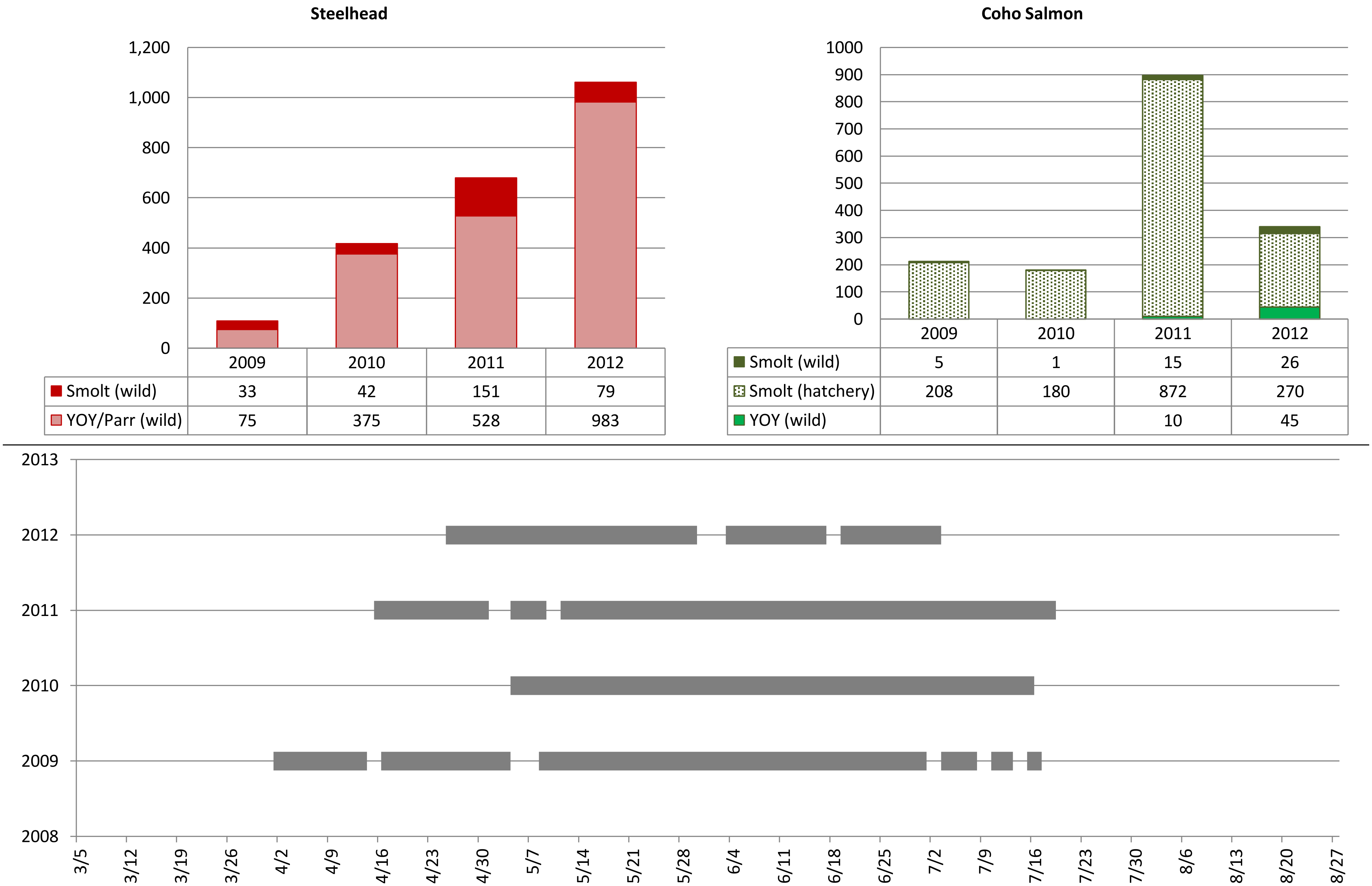


Figure 4.3.8. Weekly fork lengths of steelhead captured at lower river downstream migrant trap sites, 2012.

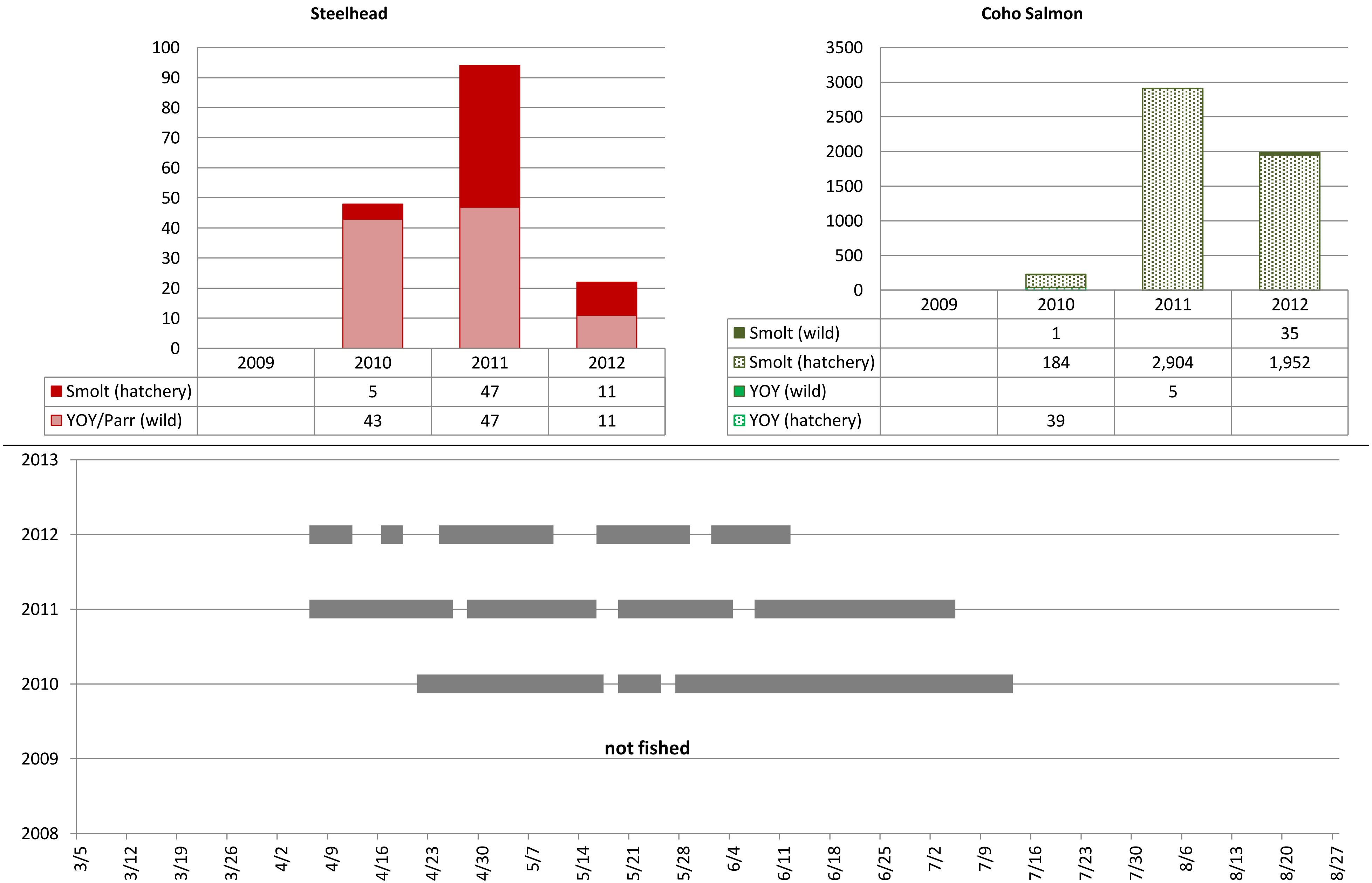


Steelhead	2009	2010	2011	2012
Smolt (wild)	33	42	151	79
YOY/Parr (wild)	75	375	528	983

Coho Salmon	2009	2010	2011	2012
Smolt (wild)	5	1	15	26
Smolt (hatchery)	208	180	872	270
YOY (wild)			10	45

Figure 4.3.9. Number of steelhead and coho salmon captured by life stage and origin at the mainstem Russian River (Mirabel) downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2009-2012.

Figure 4.3.10. Number of steelhead and coho salmon captured by life stage and origin at the Mark West Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2012.



	2009	2010	2011	2012
Smolt (hatchery)		5	47	11
YOY/Parr (wild)		43	47	11

	2009	2010	2011	2012
Smolt (wild)		1		35
Smolt (hatchery)		184	2,904	1,952
YOY (wild)			5	
YOY (hatchery)		39		

Figure 4.3.11. Number of steelhead and coho salmon captured by life stage and origin at the Dutch Bill Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2012.

	2009	2010	2011	2012
Smolt (wild)		213	175	170
YOY/Parr (wild)		4,682	1,829	3,666

	2009	2010	2011	2012
Smolt (wild)				37
Smolt (hatchery)		103	335	507
YOY (wild)			14	372
YOY (hatchery)		1,906	45	584

Figure 4.3.12. Number of steelhead and coho salmon captured by life stage and origin at the Austin Creek downstream migrant trap, (upper panels) and duration and timing of trap operation (lower panel), 2010-2012.

Chinook

In 2012 relatively few Chinook smolts were captured in Austin Creek, Dutch Bill Creek, and Green Valley Creek (377, 13 and 376 respectively). For more details on characteristics of Chinook smolts captured at Mirabel see the *Mirabel Downstream Migrant Trapping* section of this report.

Coho

At Mirabel 270 hatchery smolts, 26 wild smolts, and 45 wild parr were captured (Figure 4.3.9 and Figure 4.3. 13). At Mark West Creek 357 hatchery coho smolts, 28 wild coho smolts, and 7 wild coho parr were detected at the trap (Figure 4.3.10 and Figure 4.3. 13). A total of 1,952 hatchery and 35 wild coho smolts were captured at the Dutch Bill Creek trap which was the highest total of any of the trap sites operated in 2012 (Figure 4.3.11 and Figure 4.3. 13). At Austin Creek 507 hatchery coho smolts, 37 hatchery parr, and 372 wild parr were captured (Figure 4.3.12 and Figure 4.3. 13). Based on length data collected at the lower river traps there were at least two age groups (YOY: age-0 and parr: ≥age-1) of coho captured (Figure 4.3.14). For a more detailed analysis of downstream migrant trapping catches of coho in the Russian River see UCCE Coho Salmon Monitoring Program results for 2012.

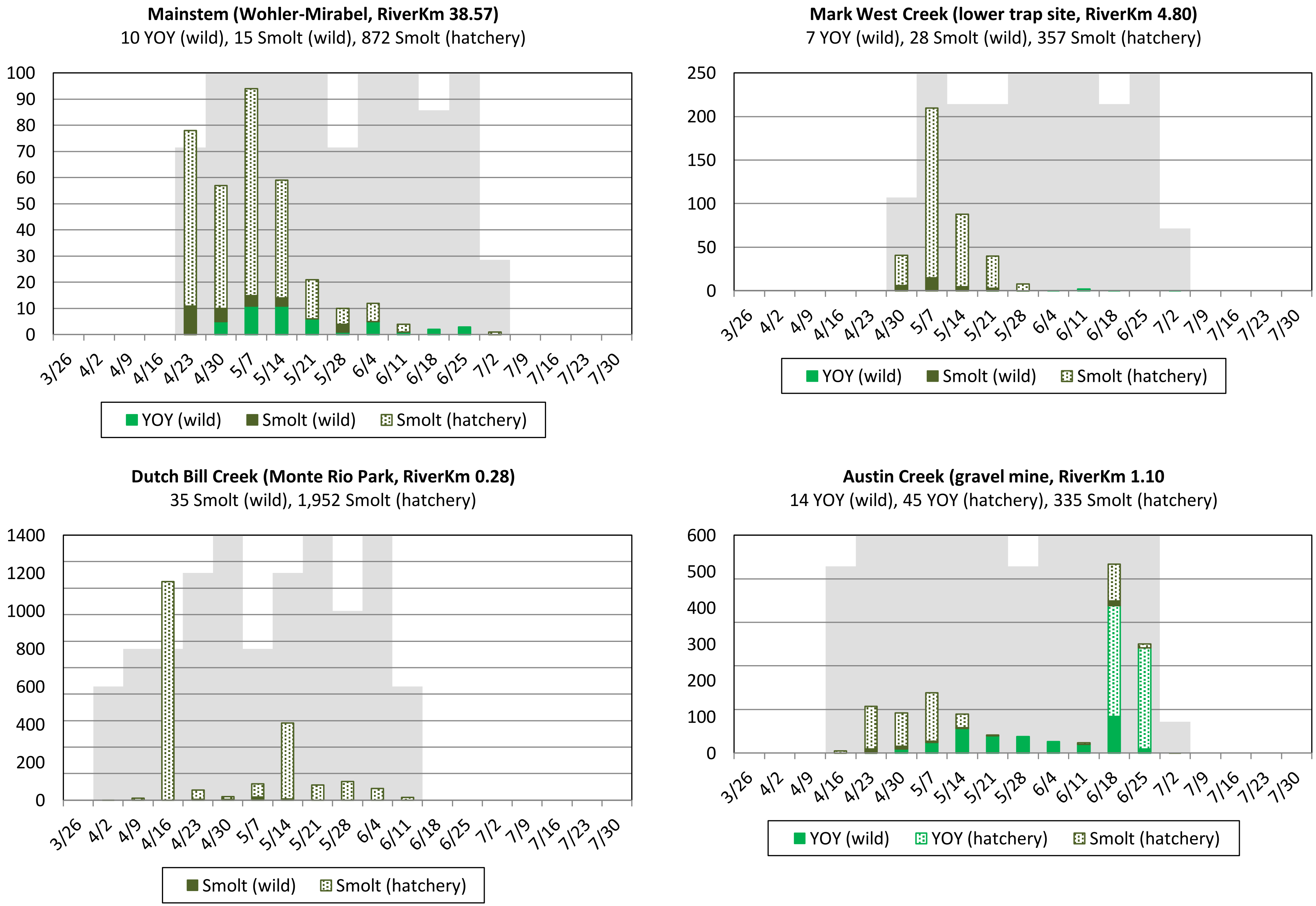


Figure 4.3. 13. Weekly capture of coho salmon by life stage at lower river downstream migrant trapping sites, 2012. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.

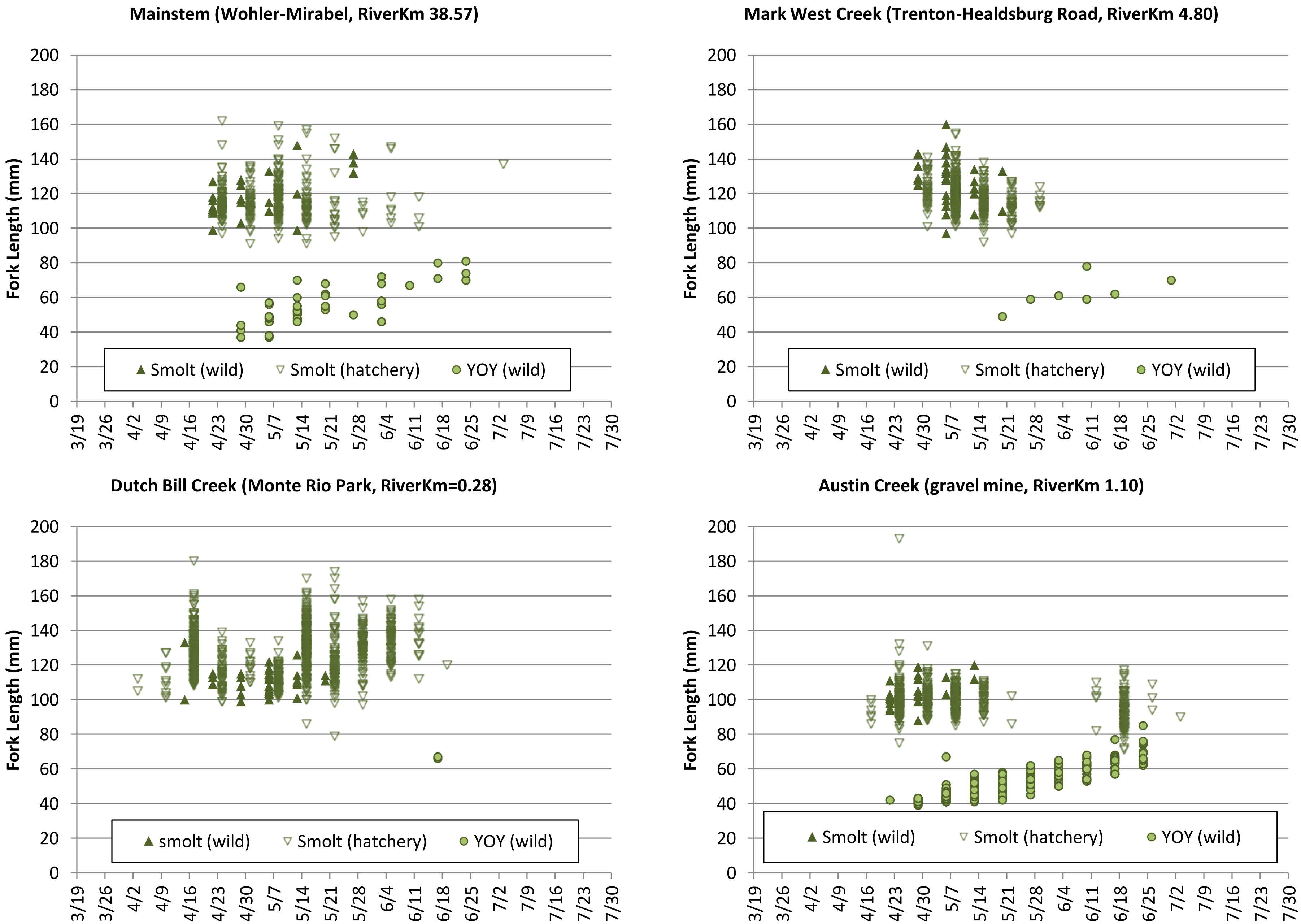


Figure 4.3.14. Weekly fork lengths of coho salmon captured at lower river downstream migrant trap sites, 2012.

Conclusions and Recommendations

Once again in 2012, the estuary fyke net video system showed low efficiency and gaps in the sampling period because of filamentous algae build-up on the fyke net and wing walls. This hampered our ability to gain an accurate picture of the timing of downstream movements of juvenile steelhead, their relative abundance and the size/age structure of the population. Species and life stage identification were also compromised by these same factors. The issues encountered in 2012 were a repeat of issues described in Manning and Martini-Lamb (2012) for the 2011 sampling season. The problems associated with the system were related to environmental factors which we were unable to control and found very difficult to correlate with the efficiency of the fyke net video system except in an anecdotal way. Therefore, if we were to rely on data from that system to make comparisons among years, we would be misled into ascribing ecologically-meaningful significance to patterns in the data that may simply be artifacts of sampling. Consequently, the Water Agency consulted with NMFS and agreed to abandon underwater video monitoring at Duncans Mills as a tool for addressing the objectives related to steelhead YOY movement into the estuary.

Russian River Biological Opinion objectives regarding the timing of estuary entry are partially met by using PIT tag detections from the paired antenna array in lower Austin Creek where antenna efficiency estimates are possible and where fish moving past that array have effectively entered the estuary. Approximately 10% of the PIT-tagged steelhead YOY that were detected moving out of Austin were later detected on the antenna array at Duncans Mills. The number of steelhead YOY originating in Austin that enter the estuary is significant (Table 4.3.3) but it is only one of the many possible tributaries that could be contributing steelhead to the estuary. Although we have been PIT-tagging steelhead YOY captured at other sites, the numbers tagged have been relatively low by comparison (361 in 2012, Table 4.3.3). Regardless, it is reasonable to expect that a similar proportion of YOY tagged at upstream sites other than Austin should be detected at a similar rate (the expectation would be 10% of 361 = 36 individuals) provided their travel path, movement mortality and propensity to move is similar to steelhead YOY tagged in Austin. From 2010-12, however, there have not been any detections of steelhead PIT-tagged at Dutch Bill, Mark West or Mirabel.

Detections of PIT-tagged fish at Duncans Mills with the partial array in place in 2012 arguably had low efficiency because it did not span the width of the river. By itself this is not an issue as long as detection efficiency can be estimated for use in expanding the number of fish detected. Unfortunately, efficiency estimates at Duncans Mills have not been possible because of the lack of a second antenna array in close proximity to the first (e.g., as is the case in Austin Creek, Figure 4.3.5). Regardless of these issues, PIT-tagging steelhead YOY at upstream locations and detecting those individuals if and when they move into the estuary (along with beach seining in the estuary itself) remain as the only viable method we know of for addressing the fish monitoring objectives in the Russian River Biological Opinion. Hence, we strongly advocate further development of the antenna array at Duncans Mills (1) to span the wetted width of the estuary at Duncans Mills and (2) by adding an additional array immediately downstream of the existing array so that we can estimate antenna efficiency and thereby account for the aforementioned environmental factors that affect sampling efficiency in an inconsistent way.

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4.4 Fish Sampling – Beach Seining

The Water Agency has been sampling the Russian River Estuary since 2004 - prior to issuance of the Biological Opinion. An Estuary fish survey methods study was completed in 2003 (Cook 2004). To provide context to data collected in 2012, we present and discuss previous years of data in this report. Although survey techniques have been similar since 2004, some survey locations and the sampling extensity changed in 2010 as required in the Biological Opinion. The distribution and abundance of fish in the Estuary are summarized below. In addition to steelhead, coho salmon, and Chinook salmon, we describe the catch of several common species to help characterize conditions in the Estuary.

Methods

Study Area

The Estuary fisheries monitoring area included the tidally influenced section of the Russian River and extended from the sandbar at the Pacific Ocean to Duncans Mills, located 9.8 km (6.1 mi) upstream from the coast (Figure 4.4.1).

Fish Sampling

A beach-deployed seine was used to sample fish species, including salmonids, and determine their relative abundances and distributions within the Estuary. The rectangular seine consisted of approximately 5 mm (¼ inch) mesh netting with pull ropes attached to the four corners. Floats on the top and weights on the bottom positioned the net vertically in the water. From 2004 to 2006 a 30 m long (100 feet) by 3 m deep (10 feet) purse seine was used. This seine was replaced in 2007 with a conventional seine (dimensions 46 m (150 ft) long by 4 m (14 ft) deep). The seine was deployed with a boat to pull an end offshore and then around in a half-circle while the other end was held onshore. The net was then hauled onshore by hand. Fish were placed in aerated buckets for sorting, identification, and counting prior to release.

Salmonids were anesthetized with Alka-seltzer tablets or MS-222 and then measured, weighed, and examined for general condition, including life stage (i.e., parr, smolt). Salmonids were identified as wild or hatchery stock (indicated by a clipped adipose fin). Tissue and scale samples were collected from some steelhead. Fish were allowed to recover in aerated buckets prior to release. Also, juvenile steelhead great than 60 mm fork length were marked by surgically implanting a passive integrated transponder (PIT) tag. PIT tags provide a unique identification to each fish. All captured steelhead were scanned with a PIT tag receiver to detect recaptured fish. This data was used to better understand the movement patterns and growth rates of steelhead in the Estuary.

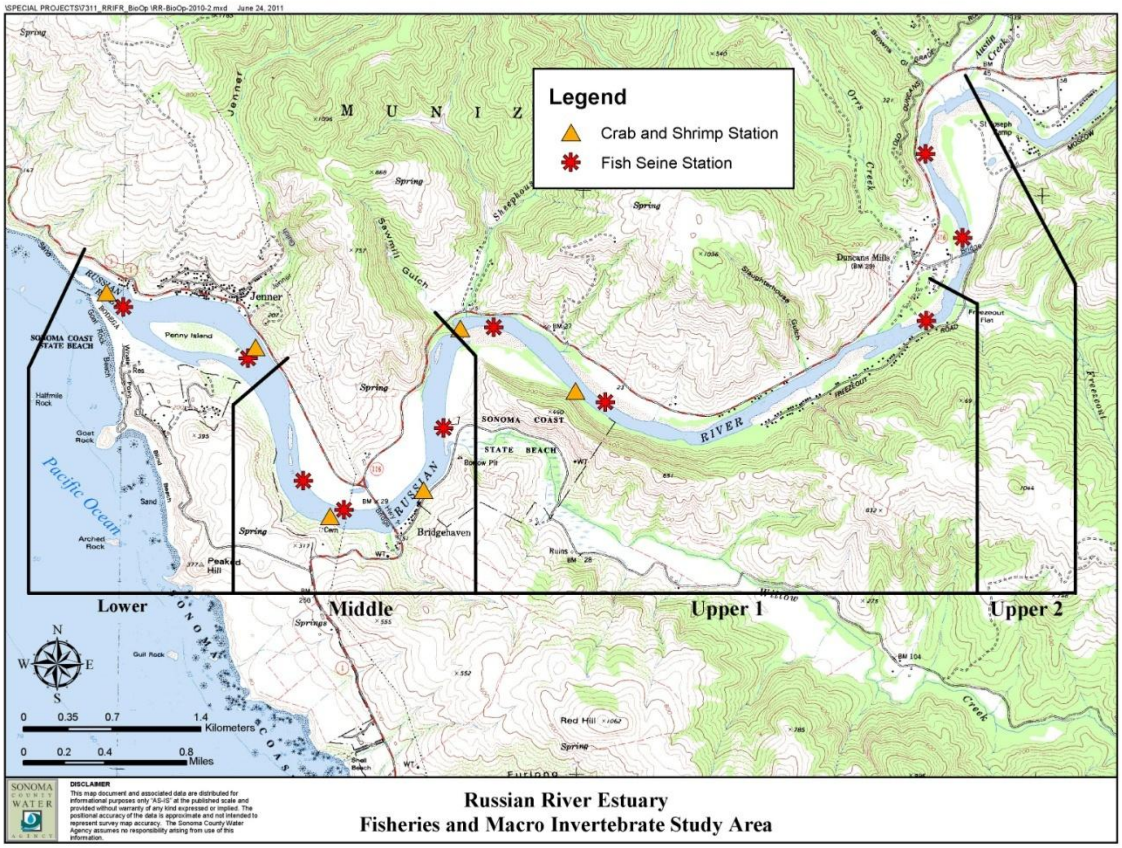

Figure 4.4.1. Russian River Estuary fisheries seining study reaches and sample sites, 2012. No macro invertebrate studies were conducted during this year.

From 2004 to 2009 eight seining stations were located throughout the Estuary in a variety of habitats based on substrate type (i.e., mud, sand, and gravel), depth, tidal, and creek tributary influences. Three seine sets adjacent to each other were deployed at each station totaling 24 seine sets per sampling event. Stations were surveyed approximately every 3 weeks from late May through September or October. Total annual seine pulls ranged from 96 to 168 sets.

Starting in 2010 fish seining sampling was doubled in effort with 300 sets completed for the season. Surveys were conducted monthly from May to October. Between 3 and 7 seine sets where deployed at 10 stations for a total of 50 sets for each sampling event. Twenty-five sets were in the lower and middle Estuary and 25 in the upper Estuary.

For data analysis the Estuary study area was divided into three reaches, including Lower, Middle, and Upper, which is consistent with study areas for water quality and invertebrate studies (Figure 4.4.1). For the fish seining study, the Upper Reach of the Estuary was divided into Upper1 and Upper2 sub-reaches to improve clarity on fish patterns. Fish seining stations were located in areas that could be sampled during open and closed river mouth conditions. Suitable seining sites are limited during closed mouth conditions due to flooded shorelines. Capture per unit effect (CPUE), defined as the number of fish captured per seine set (fish/set), was used to compare the relative abundance of fish among Estuary reaches and study years.

The habitat characteristics and locations of study reaches, fish seining stations, and number of monthly seining sets are below:

- Lower Estuary
    - River Mouth (7 seine sets): sandbar separating the Russian River from the Pacific Ocean, sandy substrate with a low to steep slope, high tidal influence.
    - Penny Point (3 seine sets): shallow water with a mud and gravel substrate, high tidal influence.
- Middle Estuary
    - Patty's Bar (3 seine sets): large gravel and sand bar with moderate slope, moderate tidal influence.
    - Bridgehaven (7 seine sets): large gravel and sand bar with moderate to steep slope, moderate tidal influence.
    - Willow Creek (5 seine sets): shallow waters near the confluence with Willow Creek, gravel and mud substrate, aquatic vegetation common, moderate tidal influence.
- Upper Estuary

    Upper1 Sub-Reach

    - Sheephouse Bar (5 seine sets): opposite shore from Sheephouse Creek, large bar with gravel substrate and moderate to steep slope, low to moderate tidal influence
    - Heron Rookery Bar (5 seine sets): gravel bank adjacent to deep water, low to moderate tidal influence.
    - Freezeout Bar (5 seine sets): opposite shore from Freezeout Creek, gravel substrate with a moderate slope, low tidal influence.

    Upper2 Sub-Reach

    - Moscow Bridge (5 seine sets): steep to moderate gravel/sand bank adjacent to shallow to deep water, aquatic vegetation common, low tidal influence.

- Casini Ranch (5 seine sets): moderate slope gravel/sand bank adjacent to shallow to deep water, upper end of Estuary at riffle, very low tidal influence.

Results

Fish Distribution and Abundance

Fish captures from seine surveys in the Russian River Estuary for 2012 are summarized in Table 4.4.1. During the nine years of study, over 175,000 fish comprised of 50 species were caught in the Estuary. In 2012, seine captures consisted of 23,964 fish comprised of 26 species. No new fish species were detected in the Estuary during 2011 fish seining.

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (Figure 4.4.2). In general, the influence of cold seawater from the ocean results in high salinity levels and cool temperatures in the Lower Reach transitioning to warmer freshwater in the Upper Reach from river inflows (Figure 4.4.3). For more detail please refer to water quality in Chapter 4.1. Fish commonly found in the Lower Reach were marine and estuarine species including topsmelt (*Atherinops affinis*), surf smelt (*Hypomesus pretiosus*), staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*). The Middle Reach had a broad range of salinities and a diversity of fish tolerant of these conditions. Common fish in the Middle Reach included those found in the Lower Reach and shiner surfperch (*Cymatogaster aggregata*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), and Russian River tule perch (*Hysterocarpus traskii pomo*), were predominantly distributed in the Upper Reach. Anadromous fish, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), which can tolerate a broad range of salinities, occurred throughout the Estuary. Habitat generalists, such as threespine stickleback (*Gasterosteus aculeatus*) and prickly sculpin (*Cottus asper*), occurred in abundance in the Estuary, except within full strength seawater in the Lower Reach.

Steelhead

During 2012, a total of 76 steelhead were captured (Table 4.4.1) in 300 seine sets. The resulting Catch per Unit Effort (CPUE) was 0.25 fish/set (Figure 4.4.4). In comparison, during 2011, a total of 120 steelhead were captured for a CPUE of 0.40 fish/set. The highest CPUE for all study years was 1.66 fish/set in 2008. All steelhead captured in 2012 were wild.

Table 4.4.1. Total fish captured by beach seine in the Russian River Estuary from May to October 2011. Each station was sampled monthly from May to October. Monthly seine sets per station are shown in parentheses.

		Seining Station										
Life History	**Species**	**River Mouth (7)**	**Penny Point (3)**	**Patty's Bar (3)**	**Bridge-haven (7)**	**Willow Creek (5)**	**Sheep-house Bar (5)**	**Heron Rookery Bar (6)**	**Freeze-out Bar (4)**	**Moscow Bridge (5)**	**Casini Ranch (5)**	**Total**
Anadromous	American shad				1				34	44	48	127
	Chinook salmon	17	14	31	91	38	3		9			203
	coho salmon		3	2	5	2			1			13
	steelhead	1			9	5			1	10	50	76
Estuarine	bay pipefish	9	8	5	25	2	10	2				61
	shiner surfperch		2	23	106	75	127	2				335
	staghorn sculpin	26	34	28	79	56	1	41	13	2	8	288
	starry flounder	23	5	20	22	13	4	6	10	4	111	218
	surfperch sp				1							1
	topsmelt			4	73							77
Freshwater	black crappie											
	bluegill											
	California roach					1		5	35	376	45	462
	common carp											
	cyprinid sp									222	32	254

Life History	Species	Seining Station										
		River Mouth (7)	Penny Point (3)	Patty's Bar (3)	Bridge-haven (7)	Willow Creek (5)	Sheep-house Bar (5)	Heron Rookery Bar (6)	Freeze-out Bar (4)	Moscow Bridge (5)	Casini Ranch (5)	Total
	fathead minnow											
	green sunfish							1				1
	hardhead										1	1
	hitch									1		1
	largemouth bass									1		1
	mosquitofish											
	Russian River tule perch									277		277
	Sacramento blackfish											
	Sacramento pikeminnow			1	22	51	58	169	25	383	9	718
	Sacramento sucker		10	6	34	12	104	1042	208	653	124	2193
	white catfish											
Marine	buffalo sculpin											
	cabezon	2										2
	English sole											
	northern anchovy											

Life History	Species	Seining Station										
		River Mouth (7)	Penny Point (3)	Patty's Bar (3)	Bridge-haven (7)	Willow Creek (5)	Sheep-house Bar (5)	Heron Rookery Bar (6)	Freeze-out Bar (4)	Moscow Bridge (5)	Casini Ranch (5)	Total
	Pacific herring	3										3
	Pacific sanddab											
	poacher sp.											
	saddleback gunnel	2										2
	sebastes sp.	6										6
	sharpnose sculpin	4										4
	silver spotted sculpin											
	surf smelt	135	1									136
	greenling sp											
	jacksmelt											
	kelp greenling											
	lingcod											
	Pacific sand sole											
	Pacific sardine											
	penpoint gunnel											
	smoothead sculpin											

Life History	Species	River Mouth (7)	Penny Point (3)	Patty's Bar (3)	Bridge-haven (7)	Willow Creek (5)	Sheep-house Bar (5)	Heron Rookery Bar (6)	Freeze-out Bar (4)	Moscow Bridge (5)	Casini Ranch (5)	Total
		Seining Station										
	snailfish sp											
	striped kelpfish											
	tidepool sculpin											
	clupeid sp											
Generalist*	prickly sculpin	25	51	172	749	280	110	218	123	90	60	1878
	threespine stickleback	392	382	1030	3011	3016	868	3690	864	3134	239	16626
Grand Total		**645**	**510**	**1322**	**4228**	**3551**	**1285**	**5176**	**1323**	**5197**	**727**	**23964**

*Prickly Sculpin counts may include small numbers of the freshwater-resident Coast Range sculpin (*Cottus aleuticus*) and riffle sculpin (*Cottus gulosus*), although neither of these species has been reported from the Estuary.

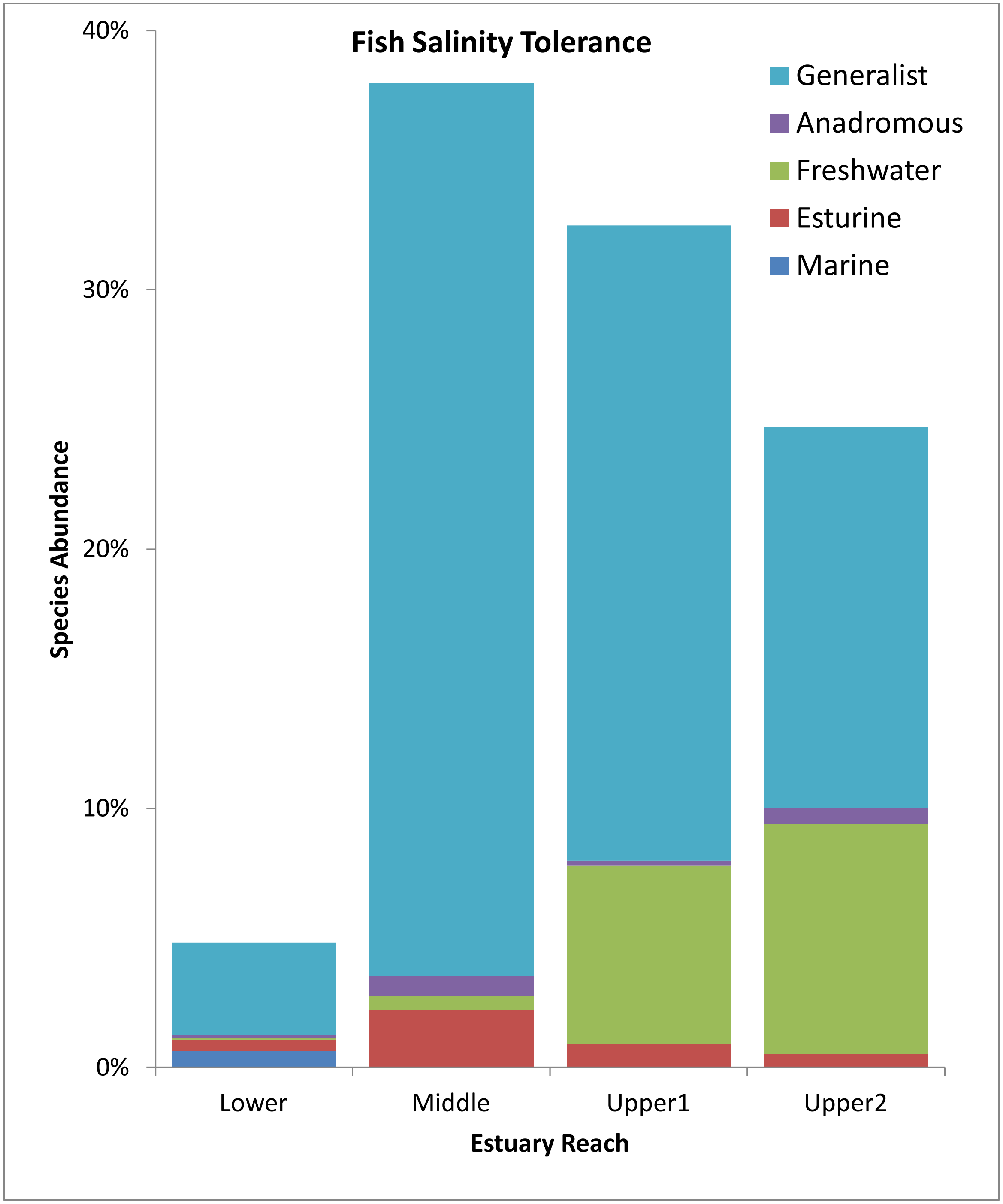

Figure 4.4.2. Distribution of fish captured by beach seine in the Russian River Estuary based on salinity tolerance and life history, 2012. Groups include: generalist species that occur in a broad range of habitats (threespine stickleback and prickly sculpin); species that are primarily anadromous; freshwater resident species; brackish-tolerant species that complete their lifecycle in estuaries; and species that are predominantly marine residents. See Table 4.4.1 for a list of species in each group.

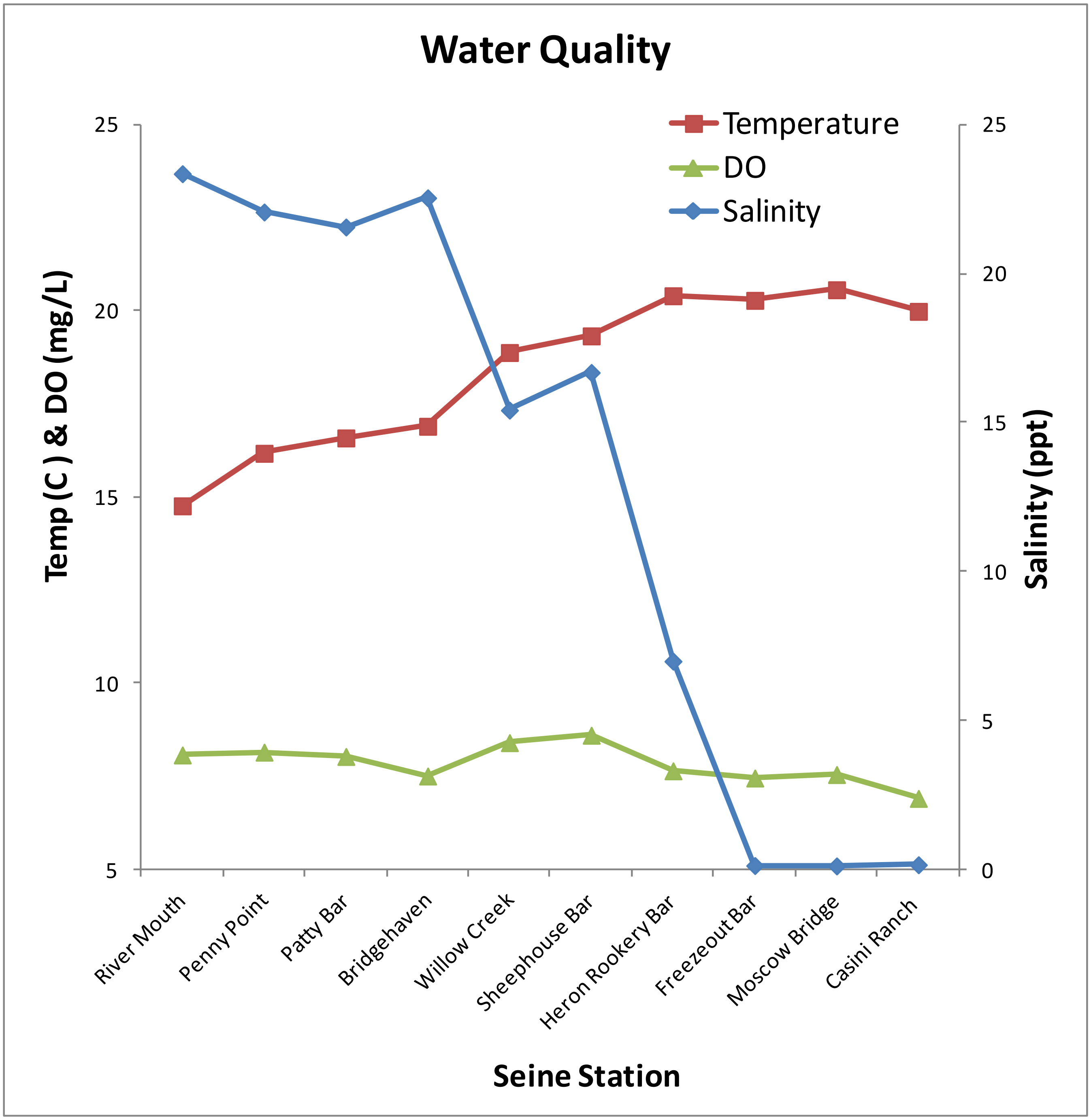

Figure 4.4.3. **Generalized water quality conditions at fish seining stations in the Russian River Estuary, 2012. Values are averages collected at 0.5 m intervals in the water column during beach seining events from May to October. Salinity values are in parts per thousand (ppt), dissolved oxygen (DO) milligrams per liter (mg/L), and water temperature celsius (C).**

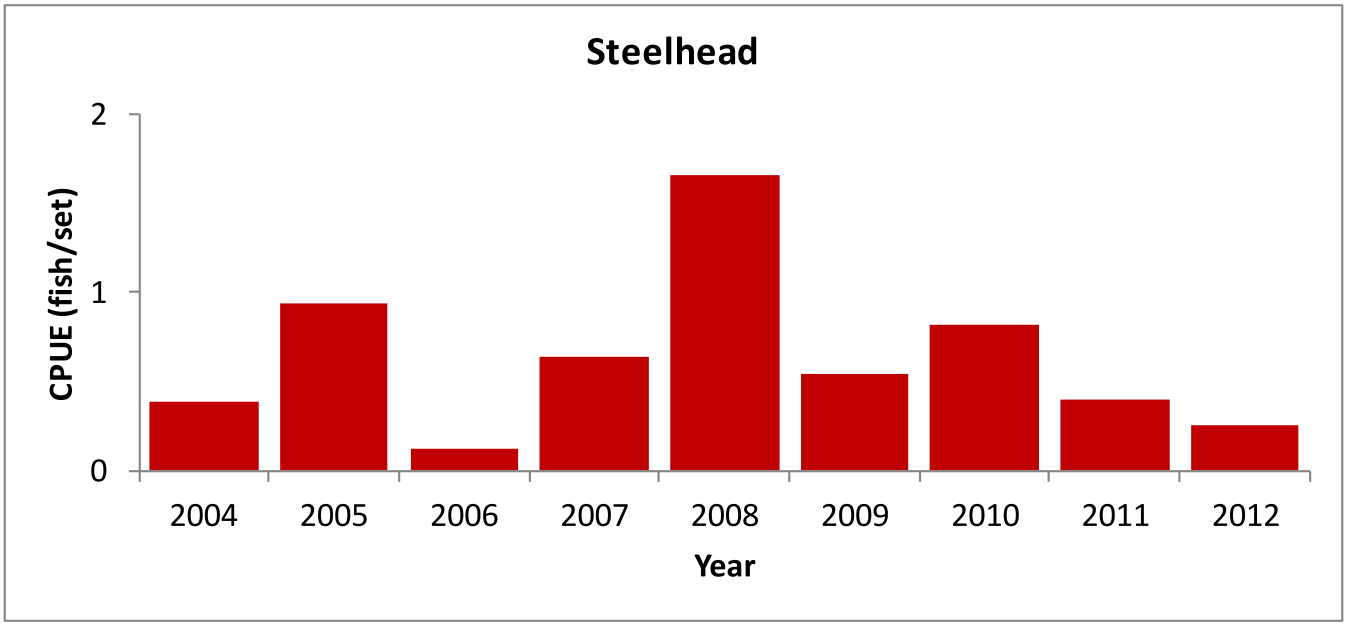

Figure 4.4.4. Annual abundance of juvenile steelhead captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets conducted yearly between May and October.

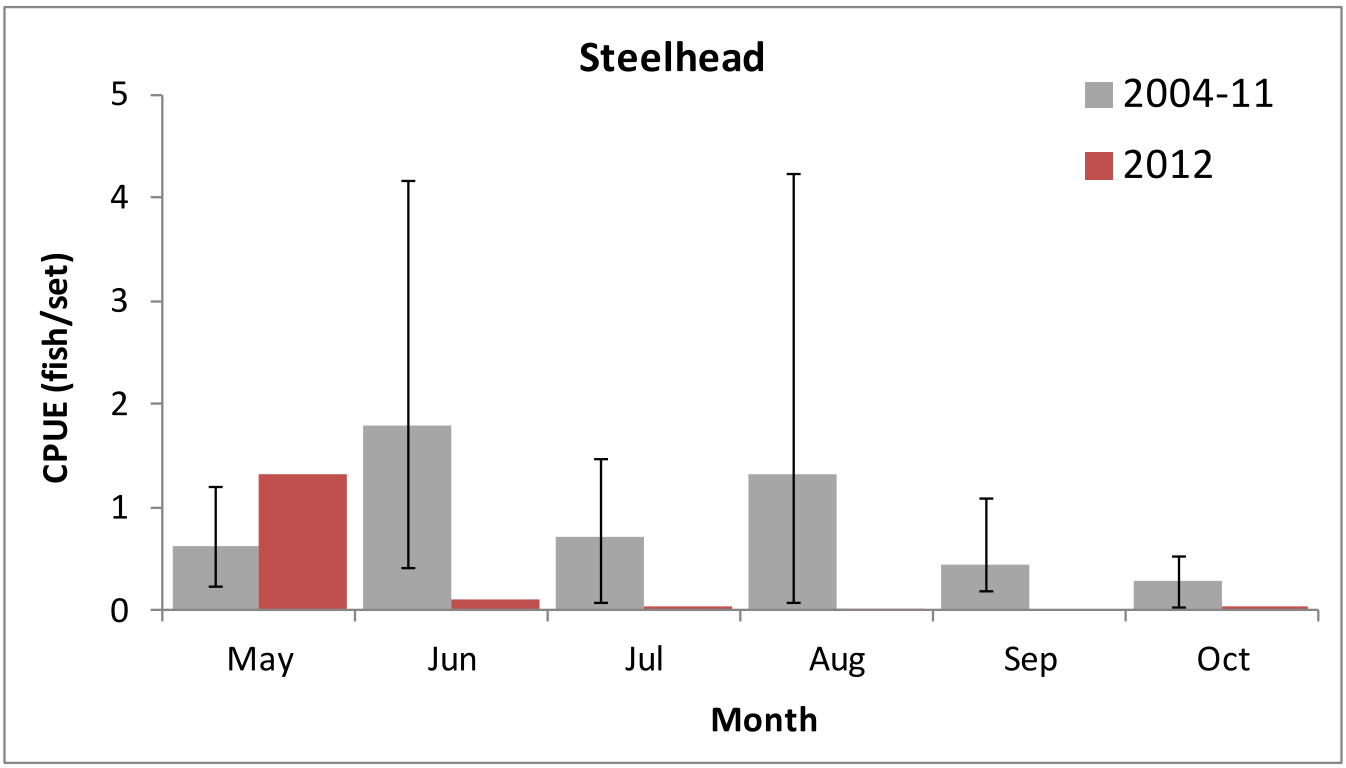

Figure 4.4.5. Seasonal abundance of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2012. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2010 were averaged and whiskers indicate minimum and maximum values.

The seasonal abundance of steelhead captured varied annually in the Estuary (Figure 4.4.5). Juvenile steelhead were captured during all survey months from May through October 2012, except September. The highest steelhead abundances are typically in June and August. However, during 2012 steelhead captures were highest during May at 1.32 fish/set. The highest capture abundance among all study years was in August at 4.3 fish/set and June at 4.2 fish/set in 2008.

Since seining surveys began in 2004, steelhead appear to have a patchy distribution and vary in abundance in the Estuary (Figure 4.4.6). In 2004 and 2006, relatively low numbers of steelhead were captured and only in the Middle and Upper1 Reaches (Upper2 Sub-Reach sampling began in 2010). While in 2005, juvenile steelhead were caught throughout most of the Estuary. Over all years surveyed, captures were typically highest in the Upper Reach with a high of 6.9 fish/set in the Upper1 Sub-Reach in 2008. During 2012 steelhead were captured in all study reaches in relatively low numbers. Captures were highest in the Upper2 Sub-Reach at 1.20 fish/set, followed on 0.28 fish/set in the Middle Reach.

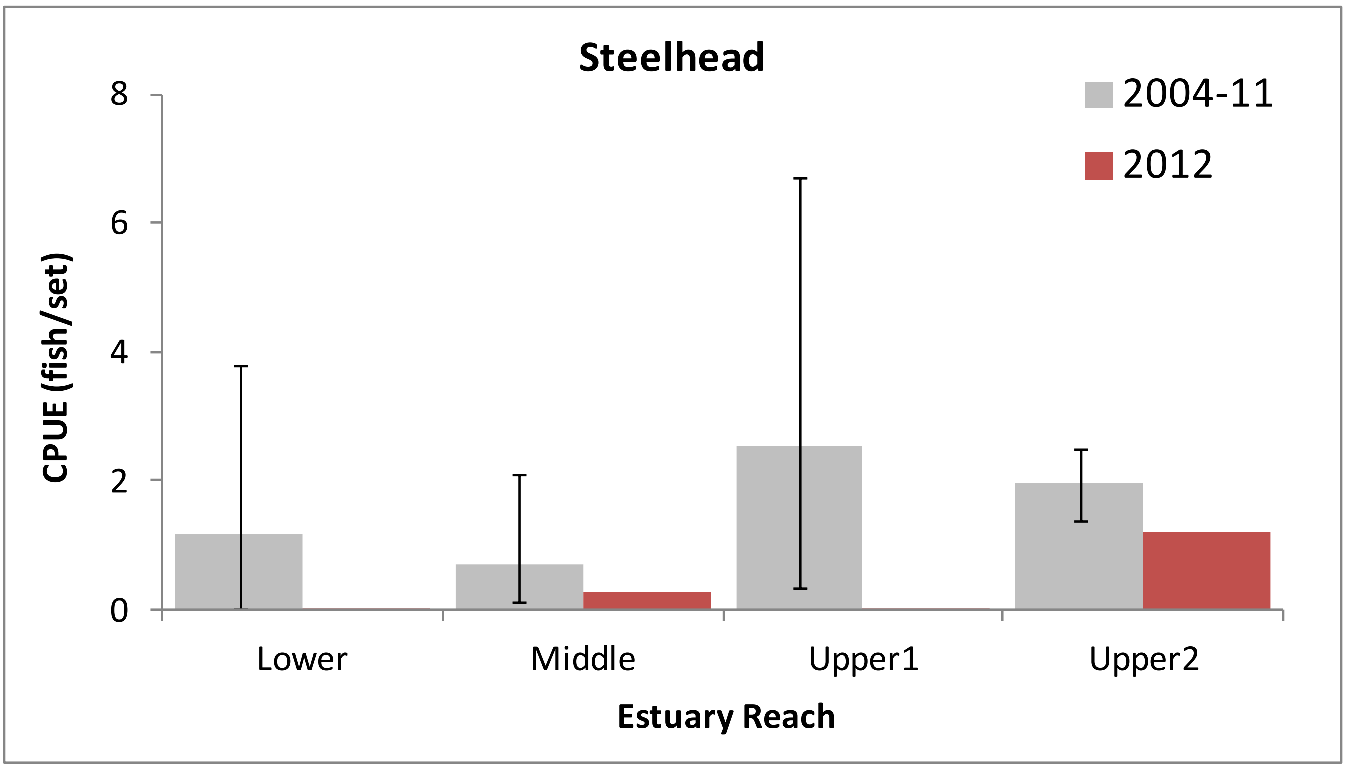

Figure 4.4.6. Distribution of juvenile steelhead captured by beach seine in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009. Data from 2004 to 2010 were averaged and whiskers indicate minimum and maximum values.

The temporal and spatial distribution of juvenile steelhead in the Estuary in 2012 was strongly influenced by large captures in the Upper2 Reach in May and June (Figure 4.4.7). None to very few steelhead were captured in the Upper1 to Lower Reaches. Most captured juvenile steelhead were age 0+ parr or age 1+ smolts and ranged in size from 63 mm to 234 mm fork length. The seasonal sizes of juvenile steelhead are shown

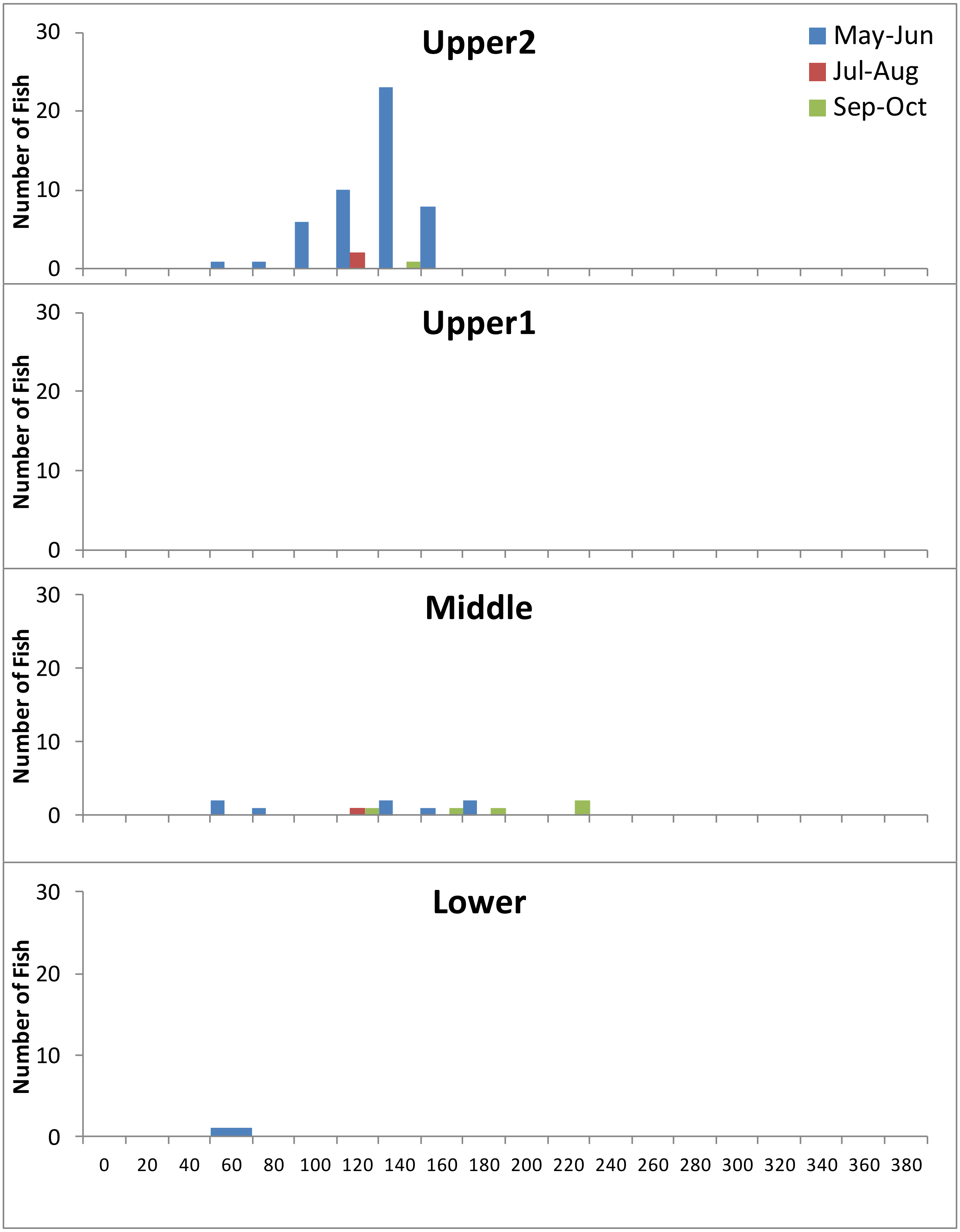

Figure 4.4.7. Length frequency of juvenile steelhead captured by beach seine in the Russian River Estuary, 2012. Fish captures are grouped by Estuary reach and month.

in Figure 4.4.8. Estuary steelhead in May appeared to consist of age 1+ smolts or pre-smolts and a few young-of-the-year less than 70 mm fork length (Figure 4.4.8). Although few steelhead were captured during mid-summer, by September captures increased and steelhead appeared to have grown rapidly. The distinct size/age groups observed in May were less apparent at the end of summer. This general pattern of rapid growth of juvenile steelhead from May to October then a decrease in numbers in October suggests that once fish obtain a large size they disperse to the ocean or move upstream out of the Estuary. Also, cooler river temperatures in October likely facilitate the upstream movement of steelhead.

In 2012, 59 juvenile steelhead captured during Estuary seining surveys were implanted with a PIT tag. An additional 16 steelhead were tagged at the mouth of Jenner Gulch, a tributary to the Lower Estuary. Also, 1,639 juvenile steelhead where PIT-tagged in Austin Creek during downstream migrant trapping studies (see Chapter 10 – Synthesis). Of the total 1,714 tagged fish, 13 were later recaptured in the Estuary. Most of these fish were tagged and recaptured at Jenner Gulch. Two fish tagged in Austin Creek were later captured in the Estuary at Sheephouse Bar in the Middle Reach or at Jenner Gulch.

The growth rates of PIT-tagged steelhead are shown in Figure 4.4.9. The average growth rate of steelhead recaptured in the Estuary in 2012 was 1.0 mm/day. Previous growth rates in the Estuary were 0.9 mm/day in 2010 snf 1.2 mm/day in 2011.

All Estuary PIT-tagged steelhead were photographed that provided a visual evaluation of growth, health, and life stage. Figures 4.4.10 and 4.4.11 show two examples of sequential photographs of steelhead tagged in Austin Creek or Jenner Gulch and then recaptured at Jenner Gulch. Juvenile steelhead #8B4E and #27D2 grew quickly with a growth rate of 1.2 mm/day. These fish were likely young-of-the-year fish that resided in the Lower Estuary most of the summer and early-fall. Steelhead #98DA was tagged in Austin Creek and recaptured 88 days later in the Middle Reach at Sheephouse Bar (Figure 4.4.12). This steelhead had a slower growth rate, at 0.5 mm/day, than juveniles that resided in the Lower Reach.

Chinook Salmon

A total of 203 Chinook salmon smolts were captured by beach seine in the Estuary during 2012 (Table 4.4.1). The abundance of smolts in the Estuary has varied since studies began in 2004 (Figure 4.4.13). Chinook salmon abundance was lowest in 2005 and 2012 at 0.7 fish/set and reached a peak in 2008 at 4.6 fish/set. Chinook salmon smolts were usually most abundant during May and June (Figure 4.4.14) and rarely encountered after July. Monthly smolt captures in 2012 were highest during May (3.7 fish/set). Very few or no smolts were captured late in the survey season in September and October. Chinook salmon smolts were distributed throughout the Estuary with captures at most sample stations and all reaches annually, except Upper2 Reach in 2012 (Figure 4.4.15).

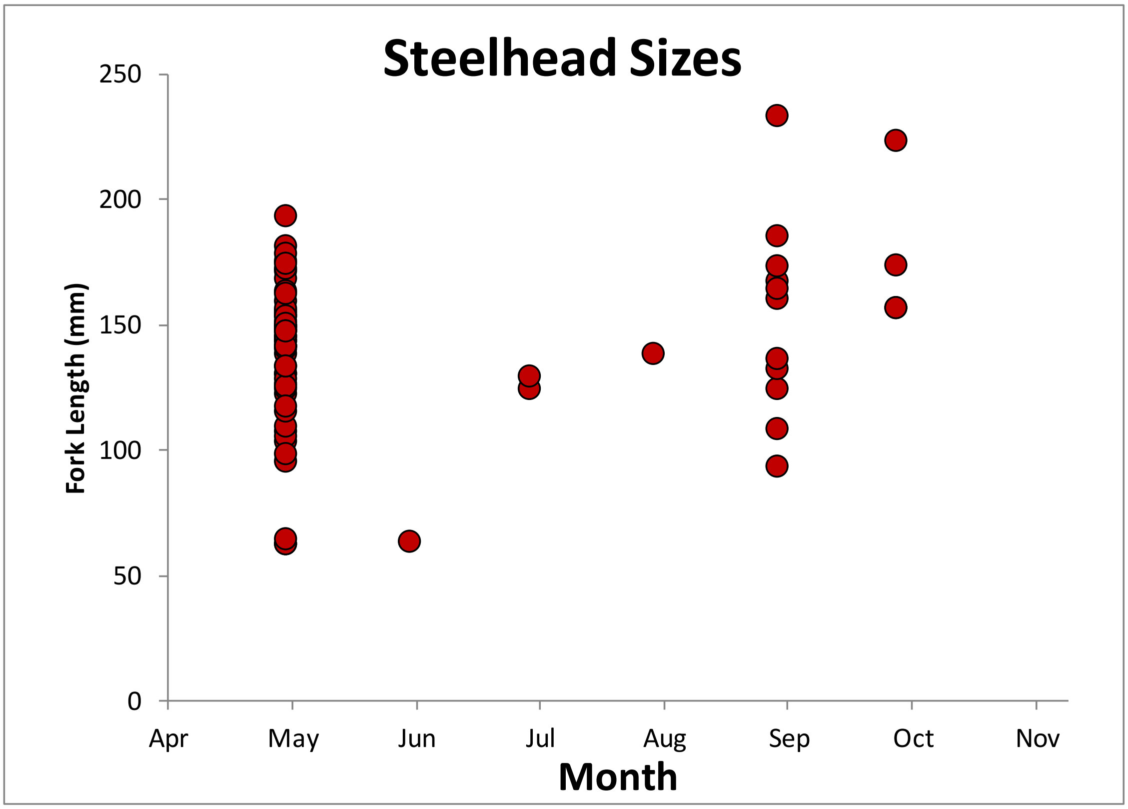

Figure 4.4.8. Juvenile steelhead sizes captured by beach seine in the Russian River Estuary, 2012.

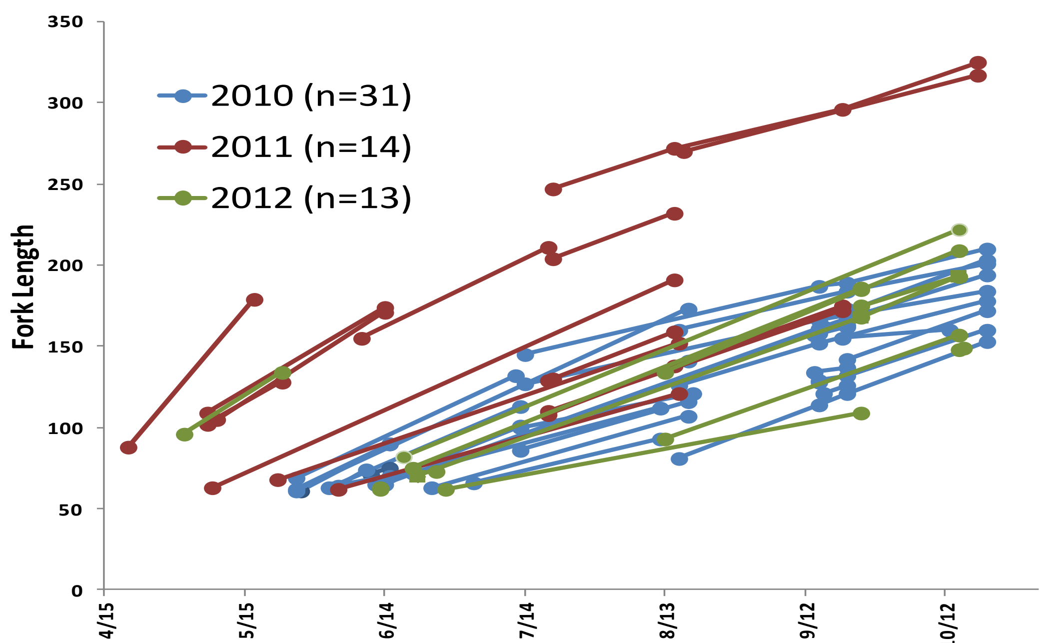

Figure 4.4 9. Growth rates of juvenile steelhead in the Estuary, 2010-2012. Fish were either PIT tagged in the Estuary or Austin Creek, a tributary to the Estuary, and then recaptured in the Estuary.

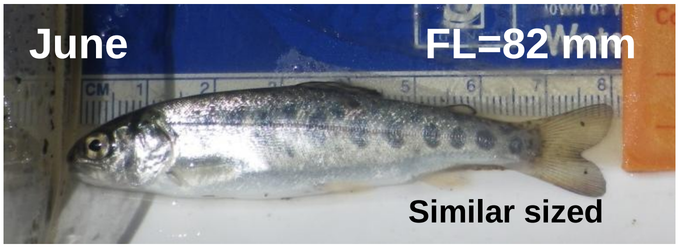

Figure 4.4. 10. Juvenile steelhead #27D2, Russian River Estuary 2012. Steelhead captured in Austin Creek on June 18 with a fork length of 82 mm and recaptured on October 15 with a fork length of 222 mm in the Lower Estuary at Jenner Gulch for a growth rate of 1.2 mm/day.

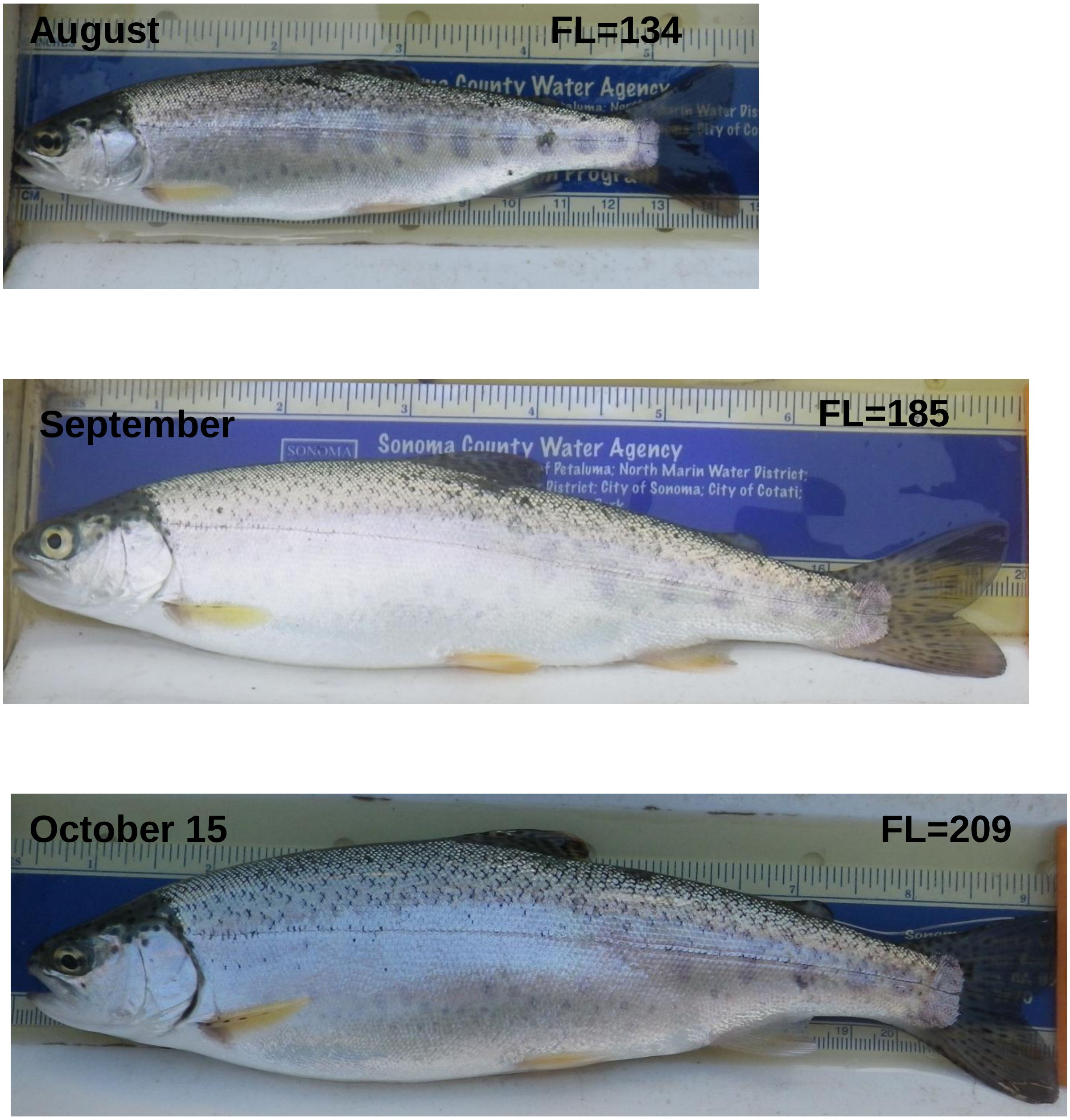

Figure 4.4. 11. Juvenile steelhead #8B4E, Russian River Estuary 2012. Steelhead captured by seine three times in the Lower Estuary at Jenner Gulch. The fish was PIT-tagged on August 13 with a fork length of 134 mm, then recaptured on September 24 at 185 mm and October 15 at 209 mm. The growth was 1.2 mm/day.

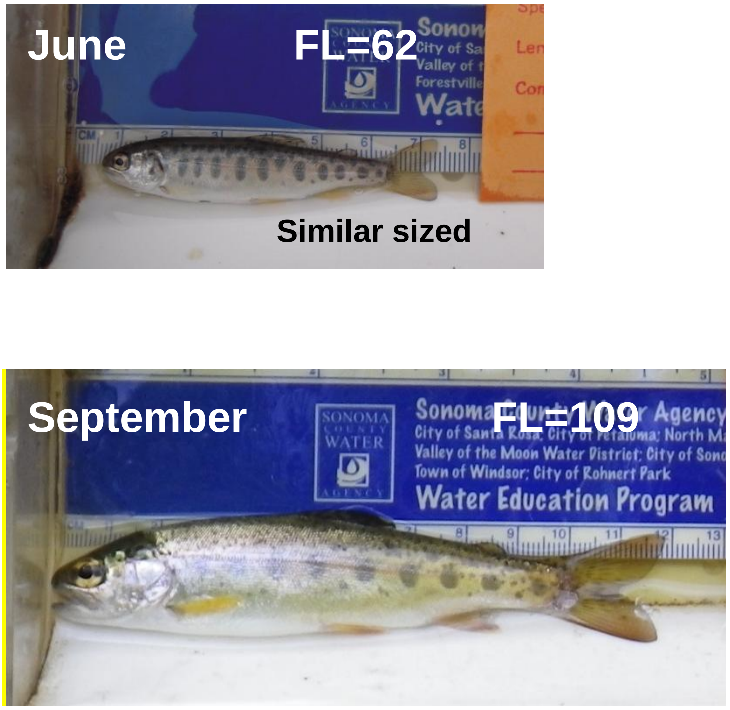

Figure 4.4.12. Juvenile steelhead #98DA, Russian River Estuary 2012. Steelhead captured and PIT tagged in Austin Creek on June 28 with a fork length of 62 mm and then recaptured on September 24 at Sheephouse Bar in the Middle Estuary at a fork length of 109 mm for a growth rate of 0.5 mm/day.

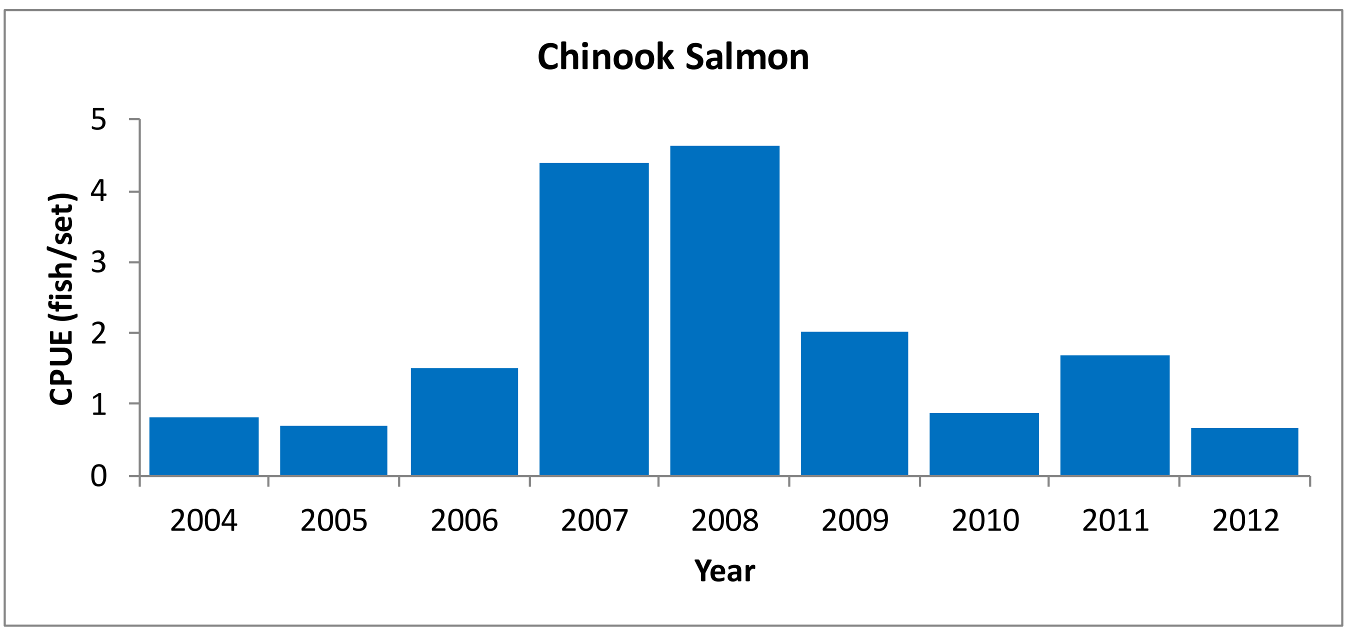

Figure 4.4.13. Annual abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly between May and October.

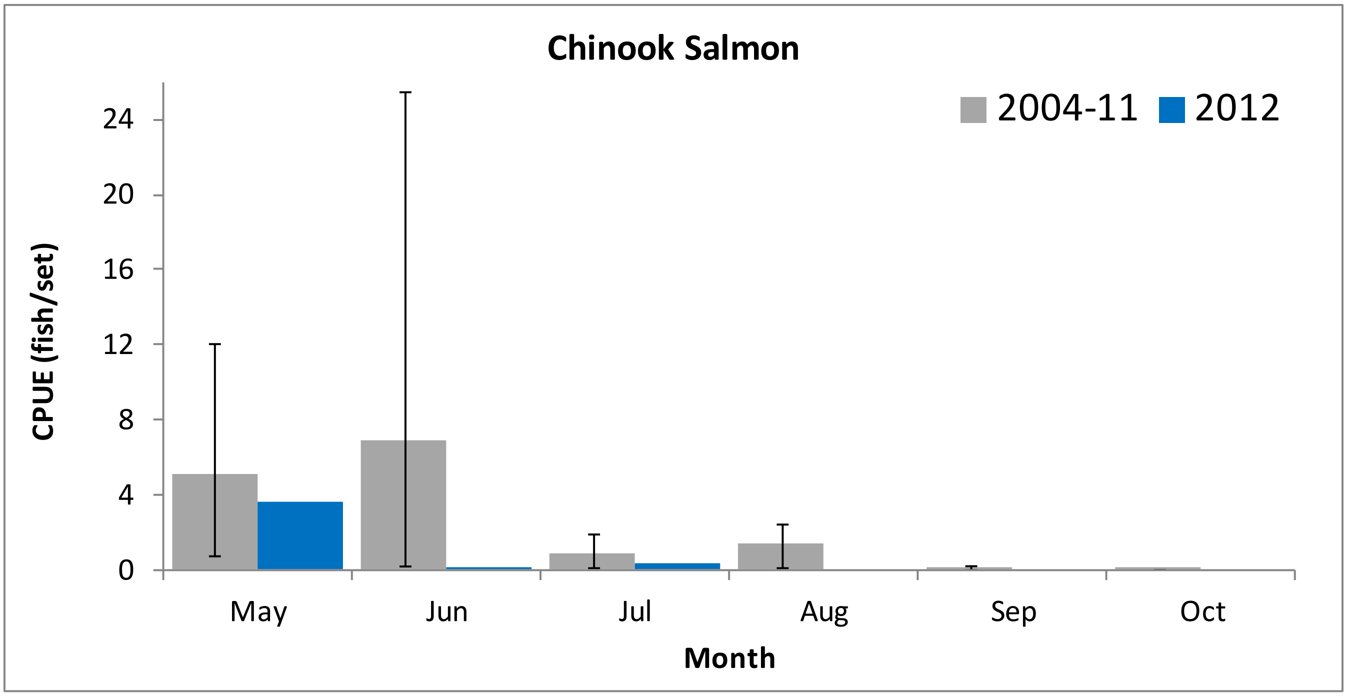

Figure 4.4.14. Seasonal abundance of Chinook salmon smolts captured by beach seine in the Russian River Estuary, 2004-2012. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

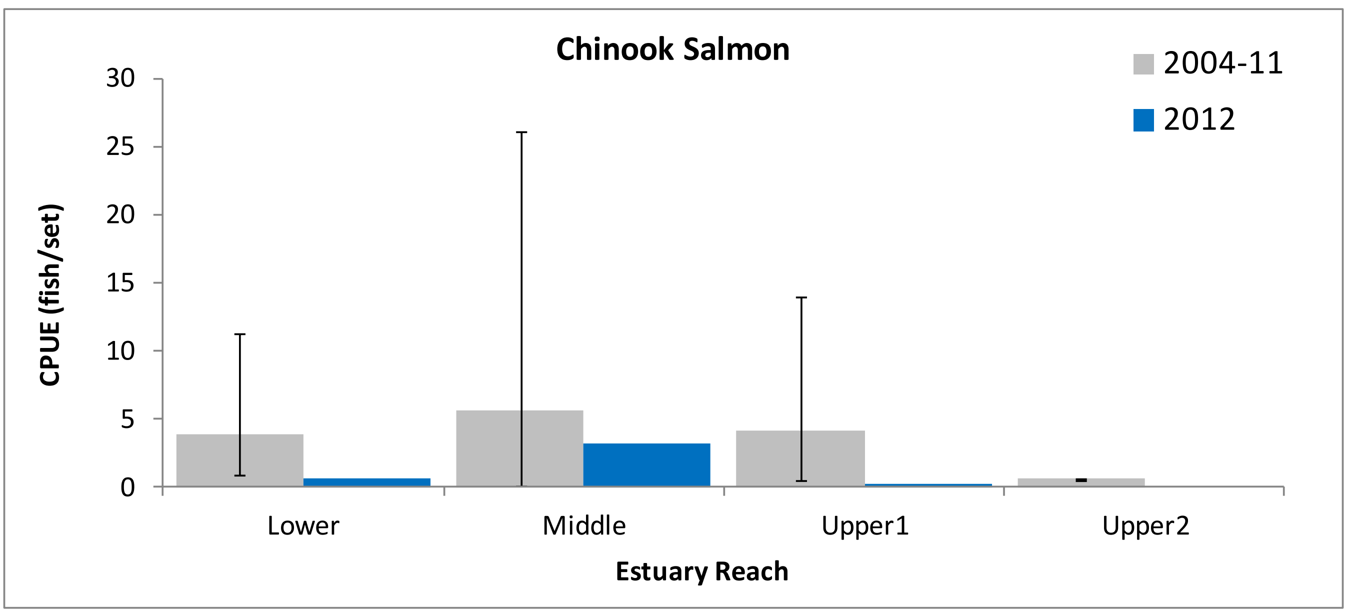

Figure 4.4.15. Spatial distribution of Chinook salmon smolts in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009.

Coho Salmon

There have been relatively few coho salmon smolts captured in the Estuary during our beach seining surveys (Figure 4.4.16). The first coho smolt captured in the Estuary was a single fish in 2006. In 2011 there was a marked increase in captures at 263 coho smolt with a CPUE of 0.9 fish/set. However, 187 of these smolts were captured during a single seine set on May 17th at Patty's Bar station in the Middle Reach. During 2012 the total captures of coho smolts was 13 for a CPUE of 0.04 fish/set. The relatively low coho captures in the Estuary are related to their scarcity in the Russian River watershed, but also the timing of our seining surveys that begin in late-May or June when most smolts have already migrated to the ocean. Nearly all smolts were captured during May (Figure4.4.17). The spatial distribution of coho smolts has varied annually (Figure 4.4.18). However, most smolts are captured in the Lower and Middle Estuary. Most captured smolts had a clipped adipose fin indicating they originated from the Coho Salmon Captive Broodstock Hatchery Program, except 2 wild coho smolts were captured in the Estuary in 2012. This program began stocking coho in local streams in 2004.

American Shad

American shad is an anadromous sportfish, native to the Atlantic coast. It was introduced to the Sacramento River in 1871, and within two decades, was abundant locally and had established populations from Alaska to Mexico (Moyle 2002). Adults spend from 3 to 5 years in the ocean before migrating upstream to spawn in the main channels of rivers. Juveniles spend the first year or two rearing in rivers or estuaries.

The annual abundance of American shad in the Estuary has ranged from 0.3 fish/set in 2005 to 24.3 fish/set in 2006 (Figure 4.4.19). During 2012, the shad CPUE was 0.4 fish/set. The seasonal occurrence of juvenile American shad followed a recurring seasonal pattern. They first appear in relatively large numbers in July and the catch usually peaks in August. Shad were distributed throughout the Estuary but were most abundant in the Upper1 and Upper2 Sub-Reaches where slightly brackish waters occur (Figure 4.4.20).

Topsmelt

Topsmelt are one of the most abundant fish in California estuaries (Baxter et al. 1999) and can tolerate a broad range of salinities and temperatures, but are seldom found in freshwater (Moyle 2002). They form schools and are often found near the water surface in shallow water. Sexual maturity is reached in 1 to 3 years and individuals can live as long as 7 to 8 years. Estuaries are used as nursery and spawning grounds and adults spawn in late-spring to summer.

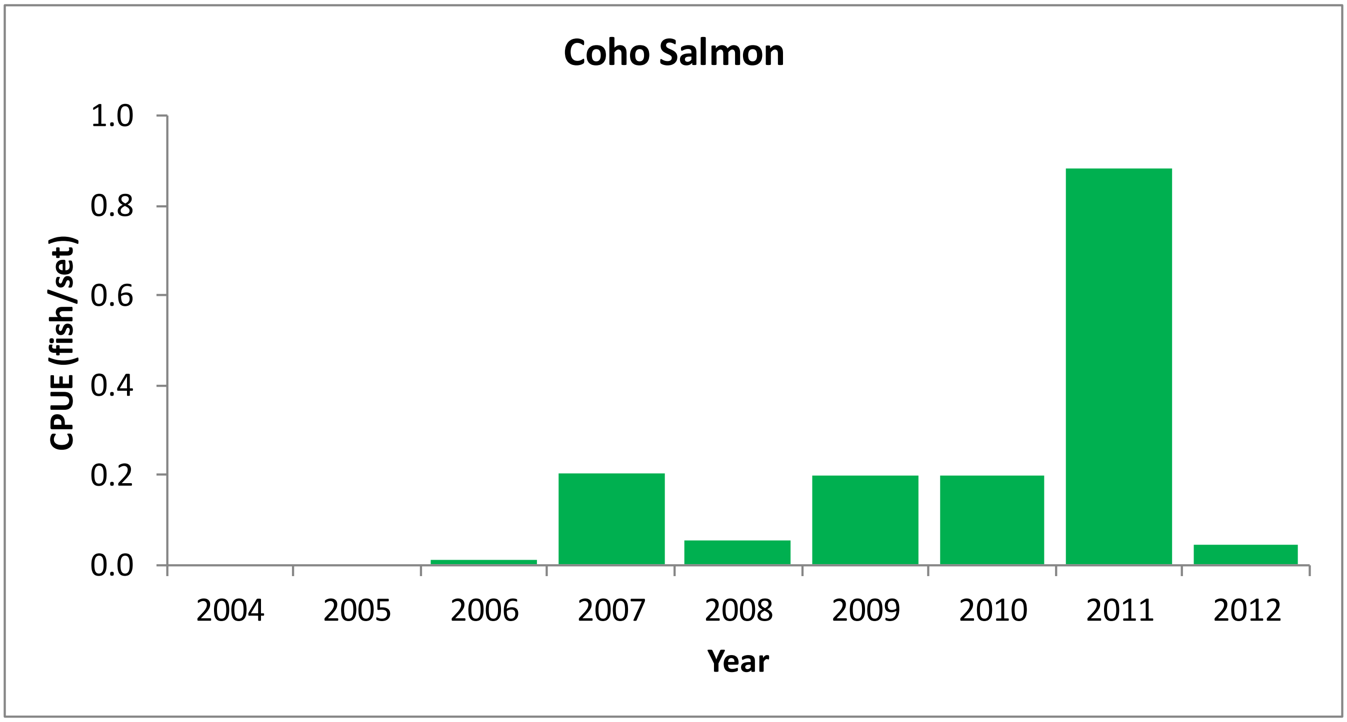

Figure 4.4.16. Annual abundance of coho salmon smolts captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

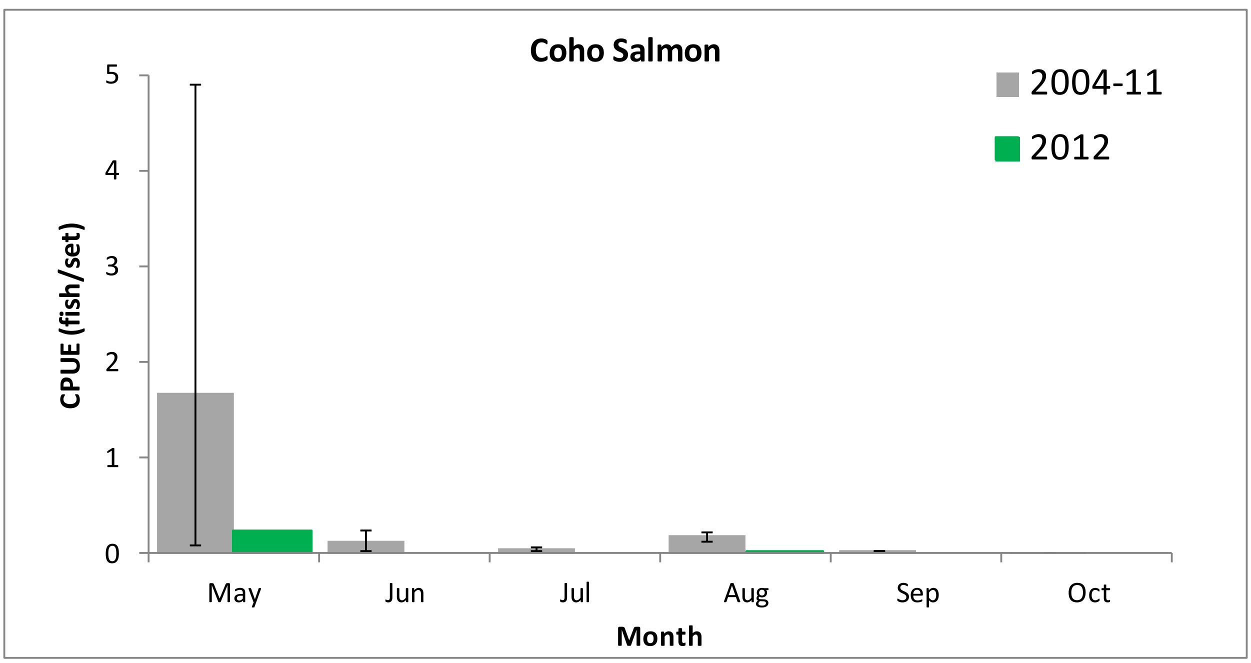

Figure 4.4.17. Seasonal abundance of coho salmon smolts captured by beach seine in the Russian River Estuary, 2004-2012. Seining events consisted of 21 to 50 seine sets approximately monthly. October surveys began in 2010. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

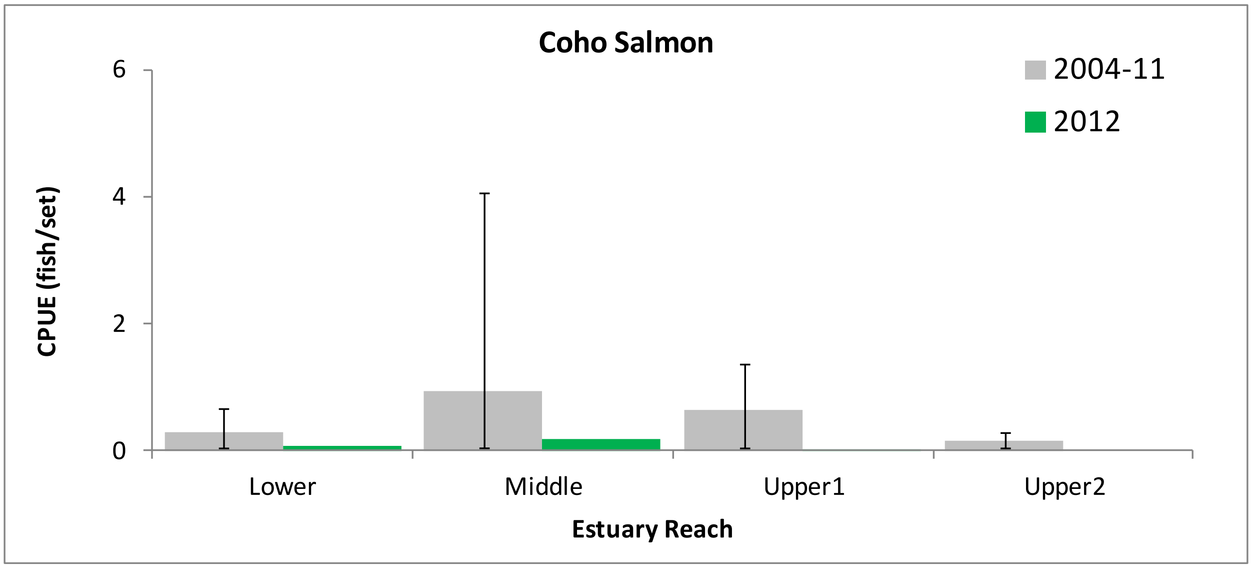

Figure 4.4.18. Spatial distribution of coho salmon smolts in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Sub-Reach (Casini Ranch and Moscow Bridge stations) from 2004 to 2009. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

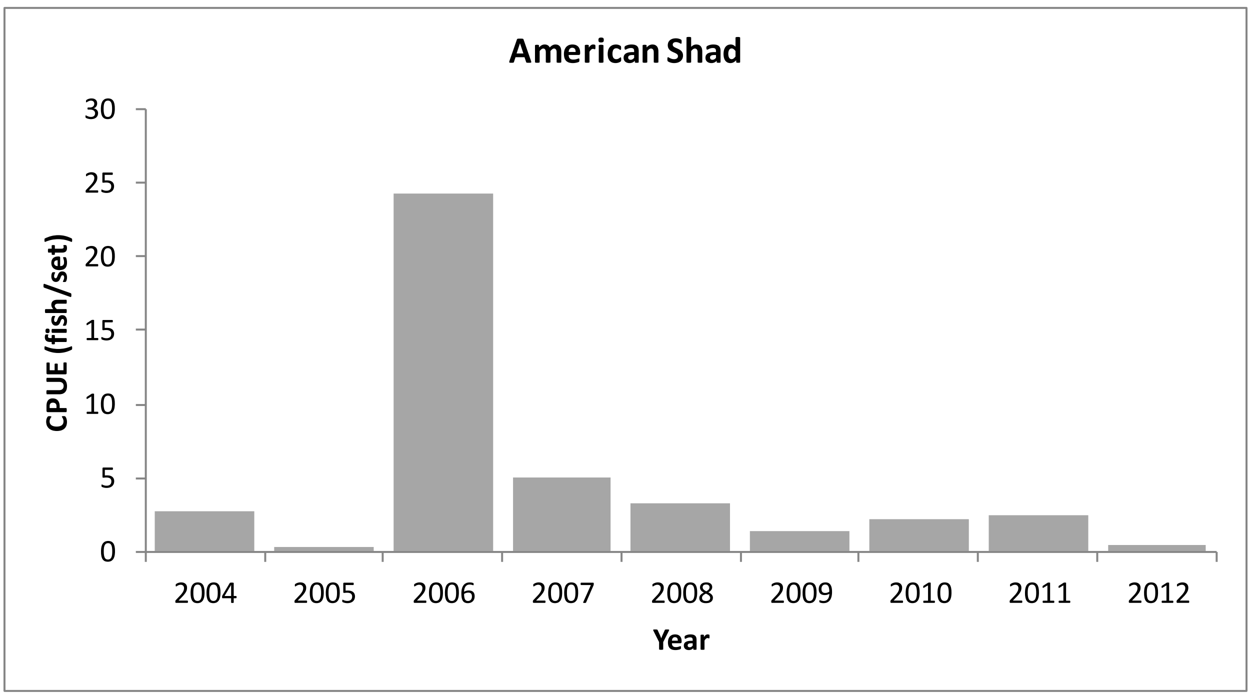

Figure 4.4.19. Annual abundance of juvenile American shad captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

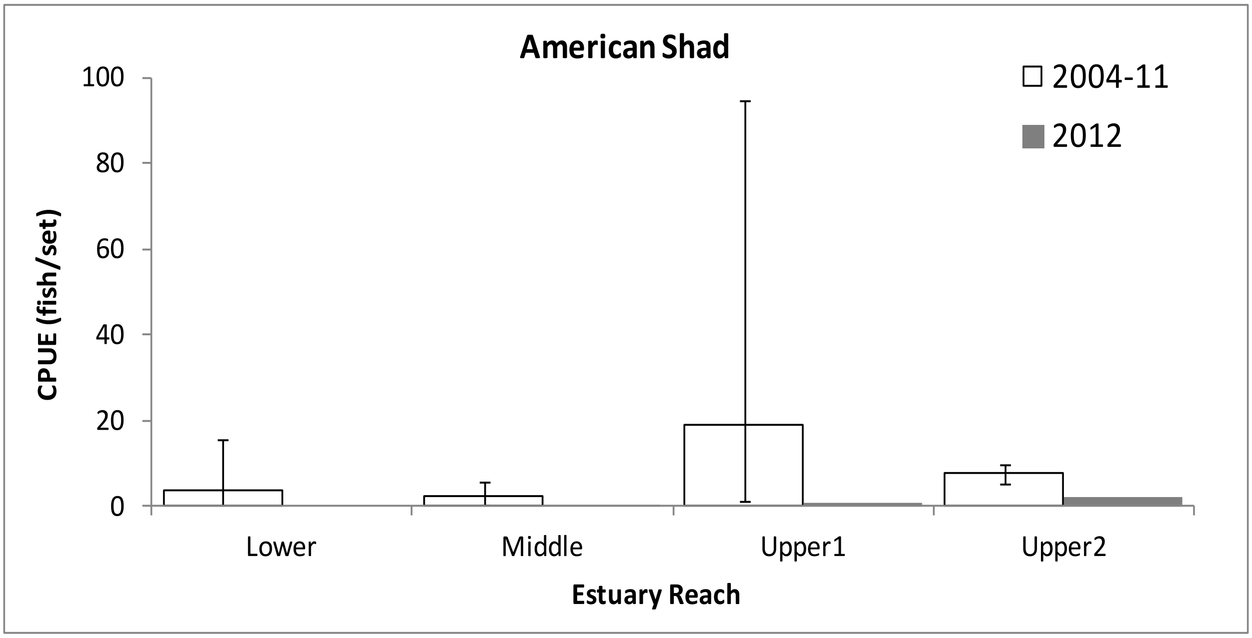

Figure 4.4.20. Spatial distribution of juvenile American shad in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

Topsmelt is a common fish in the Russian River Estuary. However, the abundance of topsmelt in the Estuary has decreased since a peak in 2006 with a CPUE of 13.4 fish/set (Figure 4.4.21). The CPUE in 2012 was 0.3 fish/set. The catch of topsmelt peaked in July and August. Topsmelt were distributed in the Lower and Middle Reaches, where brackish water conditions are common, and were seldom captured upstream where tidal influences are low (Figure 4.4.22).

Starry Flounder

Starry flounder range from Japan and Alaska to Santa Barbara in coastal marine and estuarine environments. In California, they are common in bays and estuaries (Moyle 2002). This flatfish is usually found dwelling on muddy or sandy bottoms. Males mature during their second year and females mature at age 3 or 4 (Baxter et al. 1999). Spawning occurs during winter along the coast, often near the mouths of estuaries. Young flounders spend at least their first year rearing in estuaries. They move into estuaries during the spring and generally prefer warm, low-salinity water or freshwater. As young grow, they shift to using brackish waters.

The abundance of juvenile starry flounder in the Estuary has generally decreased since 2004 and 2005 (Figure 4.4.23). Juvenile flounder have been at relatively low abundance since 2006. Seasonal changes in river outflow in combination with changing ocean conditions likely affect the strength of year classes (Baxter et al. 1999). The Estuary appears to be utilized primarily by young-of-the-year fish where most flounder captures are less than 100 mm fork length. The seasonal occurrence of starry flounder was

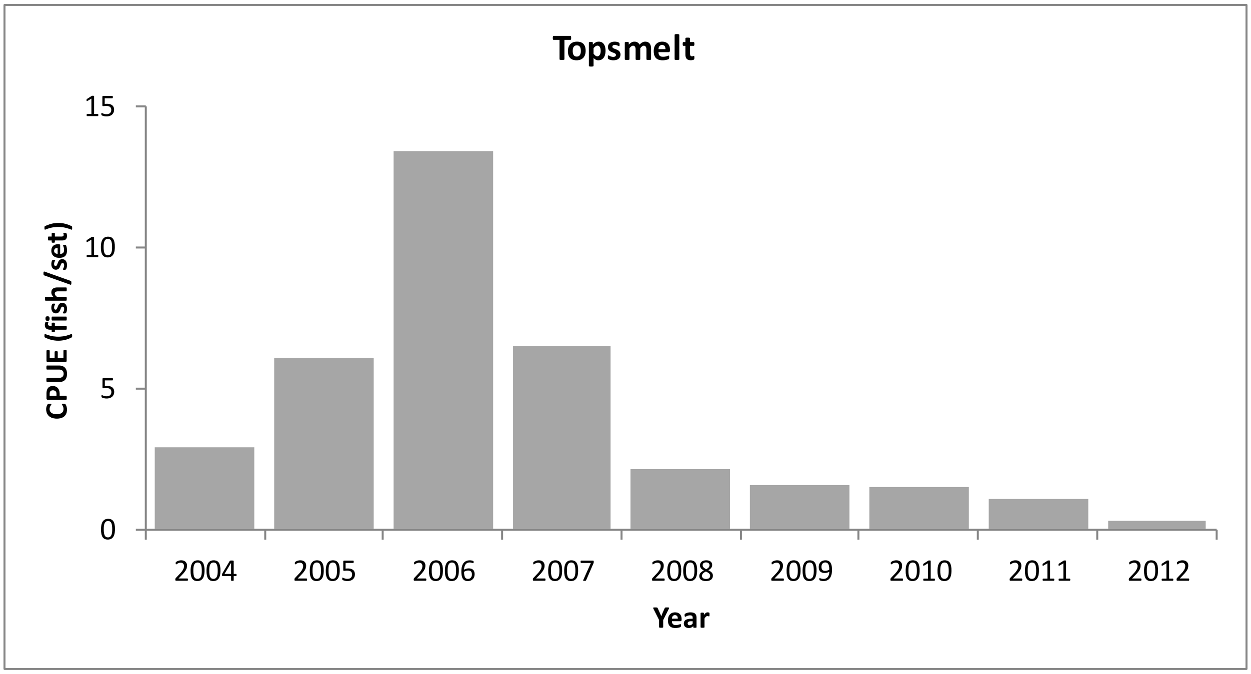

Figure 4.4.21. Annual abundance of topsmelt captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

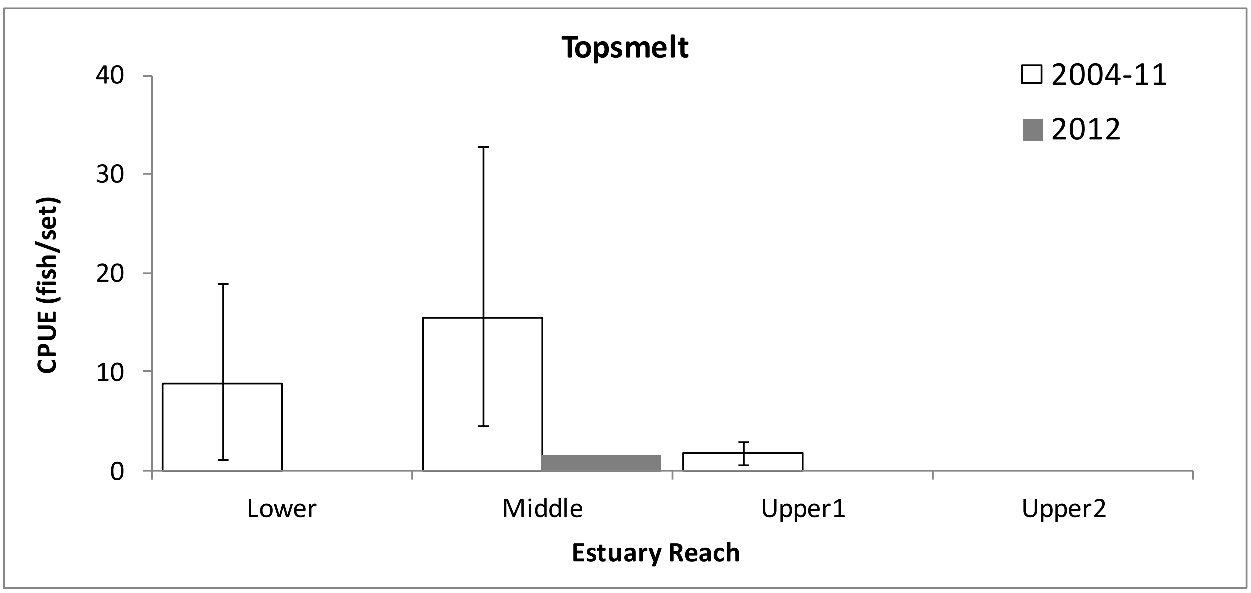

Figure 4.4.22. Spatial distribution of topsmelt in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the Upper2 Reach during 2004 and 2009. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

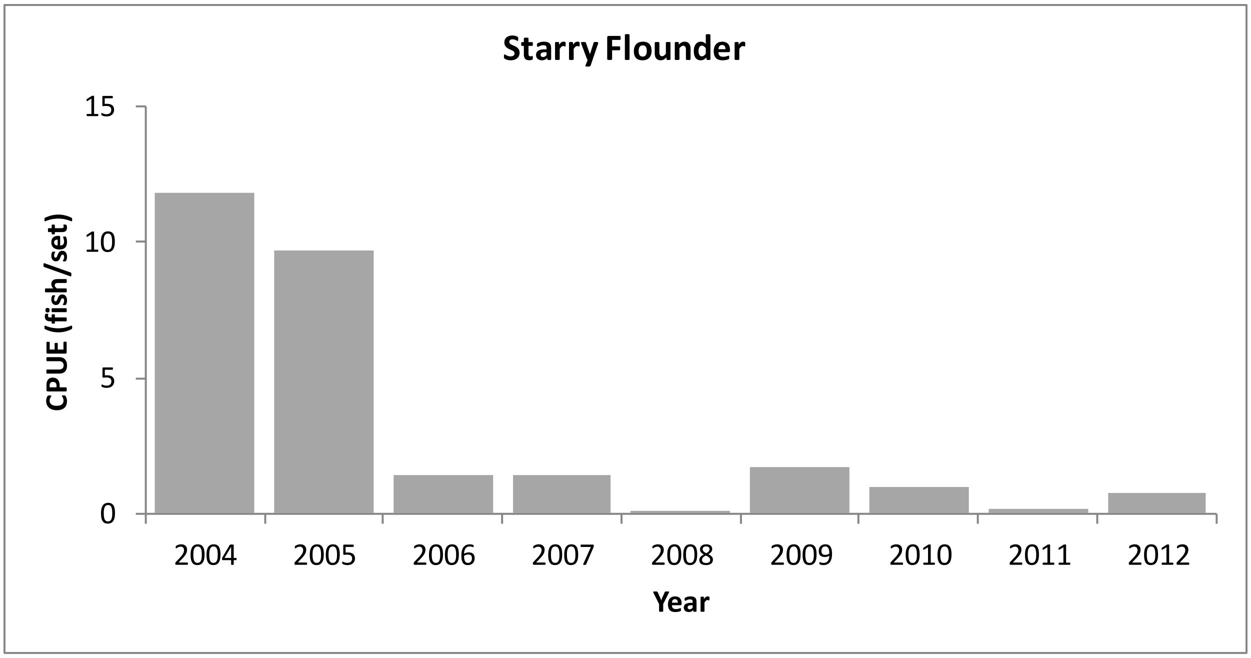

Figure 4.4.23. Annual abundance of juvenile starry flounder captured by beach seine in the Russian River Estuary. Samples are from 96 to 300 seine sets yearly from May to October.

typically highest in May and June, and then gradually decreased through September and October when few were caught. Starry flounder were distributed throughout the Estuary ranging from the River Mouth in the Lower Reach, with cool seawater conditions, to the Upper Reach, with warm freshwater (Figure 4.4.24). Starry flounder have been detected as far as Austin Creek at the upstream end of the Estuary (Cook 2006).

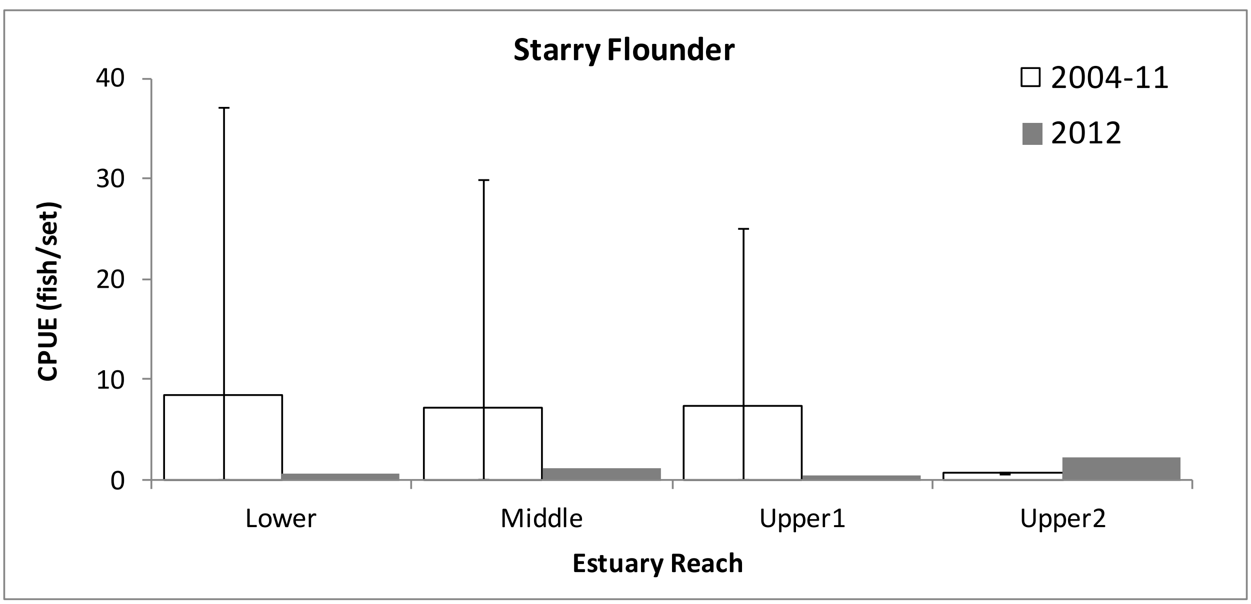

Figure 4.4.24. Spatial distribution of juvenile starry flounder in the Russian River Estuary, 2004-2012. Fish were sampled by beach seine consisting of 96 to 300 sets annually. No surveys were conducted in the upper Estuary during 2004 and 2009. Data from 2004 to 2011 were averaged. Whiskers indicate minimum and maximum values above the below the average.

Conclusions and Recommendations

Fish Sampling - Beach Seining

The results of fish surveys from 2004 to 2012 found a total of 50 fish species from marine, estuarine, and riverine origins. The distribution of species was strongly influenced by the salinity gradient in the Estuary that is typically cool seawater near the mouth of the Russian River and transitions to warmer freshwater at the upstream end. Exceptions to this distribution pattern were anadromous and generalist fish that occurred throughout the Estuary regardless of salinity levels.

All fish seining studies were conducted under predominantly open river mouth conditions allowing daily tidal circulation in the Estuary. The results of the 2012 fish studies contribute to the nine-year dataset of existing conditions and our knowledge of a tidal brackish system. This baseline data will be used to compare with a closed mouth lagoon system. However, until a prolonged lagoon is formed reducing the seining effort may be acceptable.

Although beach seining is widely used in estuarine fish studies, beach seines can only be used effectively near shore in relatively open water habitats free of large debris and obstructions that can foul or snag the net. Consequently, there is inherent bias in seine surveys (Steele et al. 2006). By design, our seining stations were located in areas with few underwater obstructions (i.e., large rocks, woody debris, etc) and this likely influenced our assessment of fish abundance and habitat use. However, the spatial and temporal aspects of our sampling do allow comparison among reaches and years.

The distribution and abundance of salmonids in the Estuary differed spatially, temporally, and by species. Steelhead were captured from May to October during each study year. PIT-tagged steelhead showed strong site fidelity to specific sites in the Estuary and grew rapidly. This indicates that steelhead rear in the Estuary under current river mouth management conditions. The synthesis in Chapter 10 provides a discussion about trends in abundance but the fluctuation in abundance of steelhead annually is likely attributed to the variability in adult spawner population size (i.e. cohort abundance), residence time of young steelhead before out-migration, and schooling behavior that affects susceptibility to capture by seining. Chinook salmon smolts spent less than half the summer rearing in the Estuary and were usually absent after July. Based on the detection of these smolts at most seining stations, they appear to use most estuarine habitats as they migrate to the ocean. In comparison, steelhead were found during the entire summer and were often found in the Upper Reach of the Estuary. However, there are sites in the Middle and Lower Estuary (e.g., Jenner Gulch confluence) where steelhead are consistently found.

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5: Dry Creek Habitat Enhancement, Planning, and Monitoring

5.1 Dry Creek Habitat Enhancement

The Biological Opinion contains an explicit timeline that prescribes a series of projects to improve summer and winter rearing habitat for juvenile coho salmon and steelhead in Dry Creek (Figure 5.1.1). During the initial three years of implementation, 2008 to 2011, the Water Agency is charged with improving fish passage and habitat in selected tributaries to Dry Creek and the lower Russian River. The status of those efforts is described in Chapter 6 of this report. For the mainstem of Dry Creek, during this initial period, the Water Agency was directed to perform fisheries monitoring, develop a detailed adaptive management plan, and conduct feasibility studies for large-scale habitat enhancement and a potential water supply bypass pipeline. The pipeline feasibility study was completed in 2011 and is reported in Martini-Lamb and Manning 2011.

In 2012, the Water Agency began construction of the first phase of the Dry Creek Habitat Enhancement Demonstration Project. A second phase of the Dry Creek Habitat Enhancement Demonstration Project was constructed in 2013 with a third and final phase scheduled for construction in 2014. The Dry Creek Habitat Enhancement Demonstration Project consists of a variety of habitat enhancement projects along a section of Dry Creek a little over one mile in length in the area centered around Lambert Bridge. Concurrently, the U.S. Army Corps of Engineers completed construction in 2013 of a habitat enhancement project on U.S. Army Corps of Engineers owned property just below Warm Springs Dam (Reach 15 area).

Habitat Enhancement Feasibility Study

The Water Agency regulates summer releases from Warms Springs Dam along a 14 mile reach of Dry Creek from Lake Sonoma to the Russian River. This abundant, cool, high quality water has tremendous potential to enhance the Russian River's coho and steelhead population but it flows too swiftly to provide maximum habitat benefit. By modifying habitat conditions to create refugia from high water velocities along 6 miles of Dry Creek, NMFS and DFG assert that water supply releases can continue at current discharge levels of approximately 100 cubic feet per second (cfs) and potentially historic discharge levels up to 175 cfs.

To plan large scale enhancement of the Dry Creek channel, the Water Agency has retained Inter-Fluve, Inc. to conduct extensive field surveys and produce a series of reports detailing habitat enhancement opportunities along Dry Creek. Interfluve's work is being conducted in three phases: 1) inventory and assessment of current conditions; 2) feasibility assessment of habitat improvement approaches; and 3) conceptual design

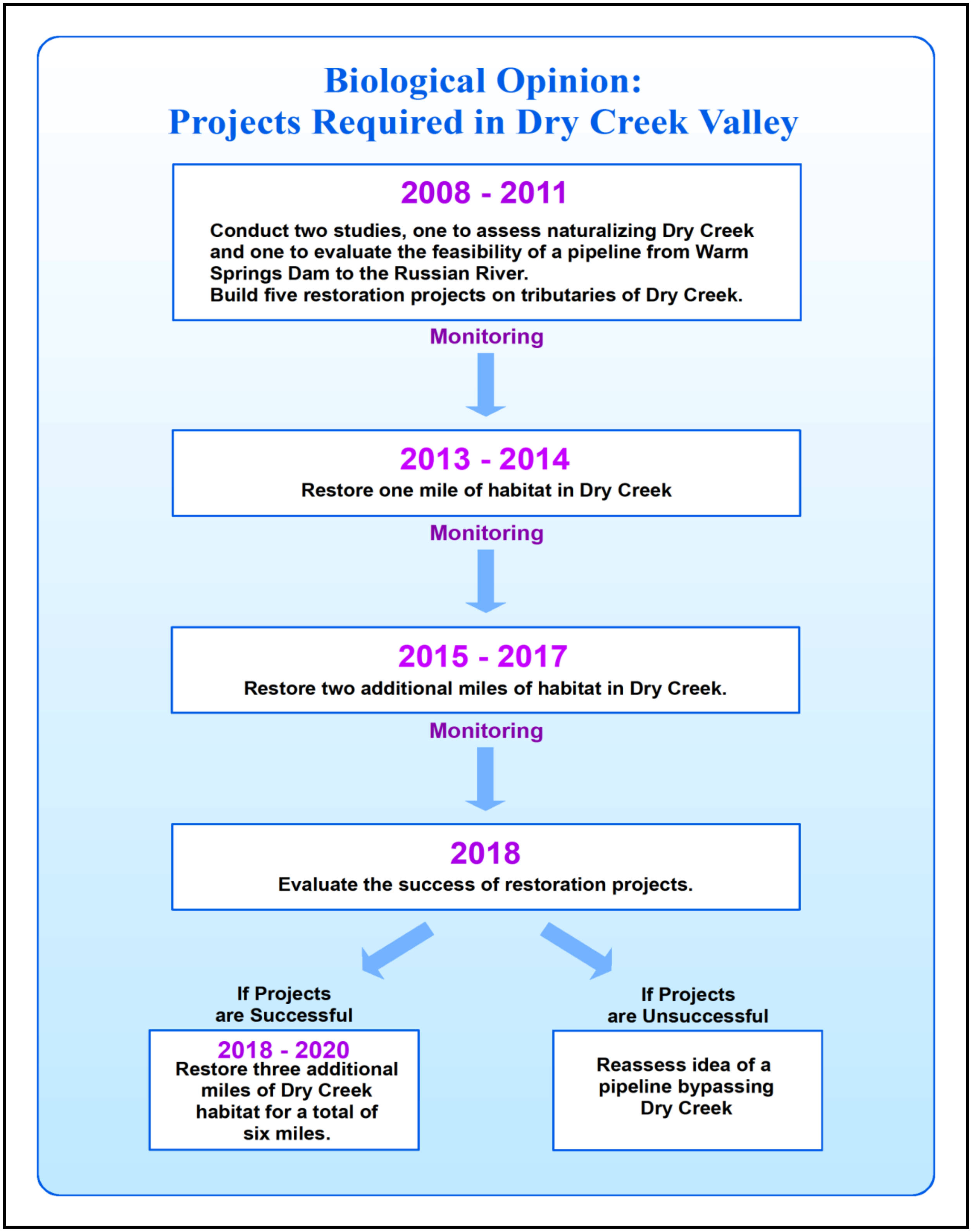


Figure 5.1.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

of habitat approaches deemed feasible. All three reports have been completed and can be viewed at http://www.scwa.ca.gov/drycreek/.

During 2011, Interfluve developed the Dry Creek Fish Habitat Enhancement Conceptual Design Report. The final report was released to the public in July 2012 and identifies 26 sub reaches along Dry Creek as potential areas for construction of low velocity habitat with depth and cover characteristics conducive to rearing juvenile coho salmon and steelhead. The opportunities identified in the report are distributed throughout the 14 mile length of Dry Creek. However, different reaches of Dry Creek present unique geomorphic and hydrologic constraints and Interfluve divided the stream into upper, middle, and lower segments. In the upper segment (mile 11 to 13.7), the influence of Warm Springs Dam on streamflow, substrate, and channel dimensions is most pronounced. The stability of this reach provides opportunities for long lasting "constructed" habitat features such as side channels, backwaters, and log structures. In the lower segment between Westside Road Bridge and the confluence with the Russian River (mile 0 to 3), conditions are amenable to constructing projects designed to let natural river processes develop habitat over time. The middle segment between Pena Creek and Westside Road (miles 3 to 11), has opportunities for both constructed habitat and river process based approaches.

The Concept Design report includes a description of current habitat conditions, modeled indundations at high flow, maps and graphics depicted proposed summer and winter habitat features, and a preliminary cost estimate for each of the 26 enhancement sub reaches along Dry Creek (Figure 5.1.2). All of the sub reaches are ranked according to the potential quantity of summer and winter coho rearing habitat they provide (Table 5.1.1). This ranking does not, however, include implementation considerations such as relative cost, landowner willingness and accessibility, and continuity or predicted longevity of constructed features. Figure 5.1.3 illustrates the two step process that will be employed to select enhancement reaches on Dry Creek.

Demonstration Project

As described in the Public Outreach Chapter of this report, the Water Agency must engage a diverse group of stakeholders to implement the Biological Opinion. Dry Creek is held almost entirely in private ownership and Water Agency staff must work in concert with landowners of more than 170 parcels to study, plan, and construct habitat enhancements. The Biological Opinion's 5 year timeline prior to construction of the first mile of habitat enhancement acknowledges this challenge and the depth of study, planning, and environmental compliance required for implementation. A forward looking group of property owners along a one mile stretch of the stream near Lambert Bridge, in the middle of Dry Creek Valley, approached the Water Agency with the opportunity to advance the schedule and demonstrate habitat enhancement techniques in their reach of the stream (Figure 5.1.4). The Water Agency has welcomed this opportunity, and is working on implementing the Dry Creek Habitat Enhancement Demonstration Project.

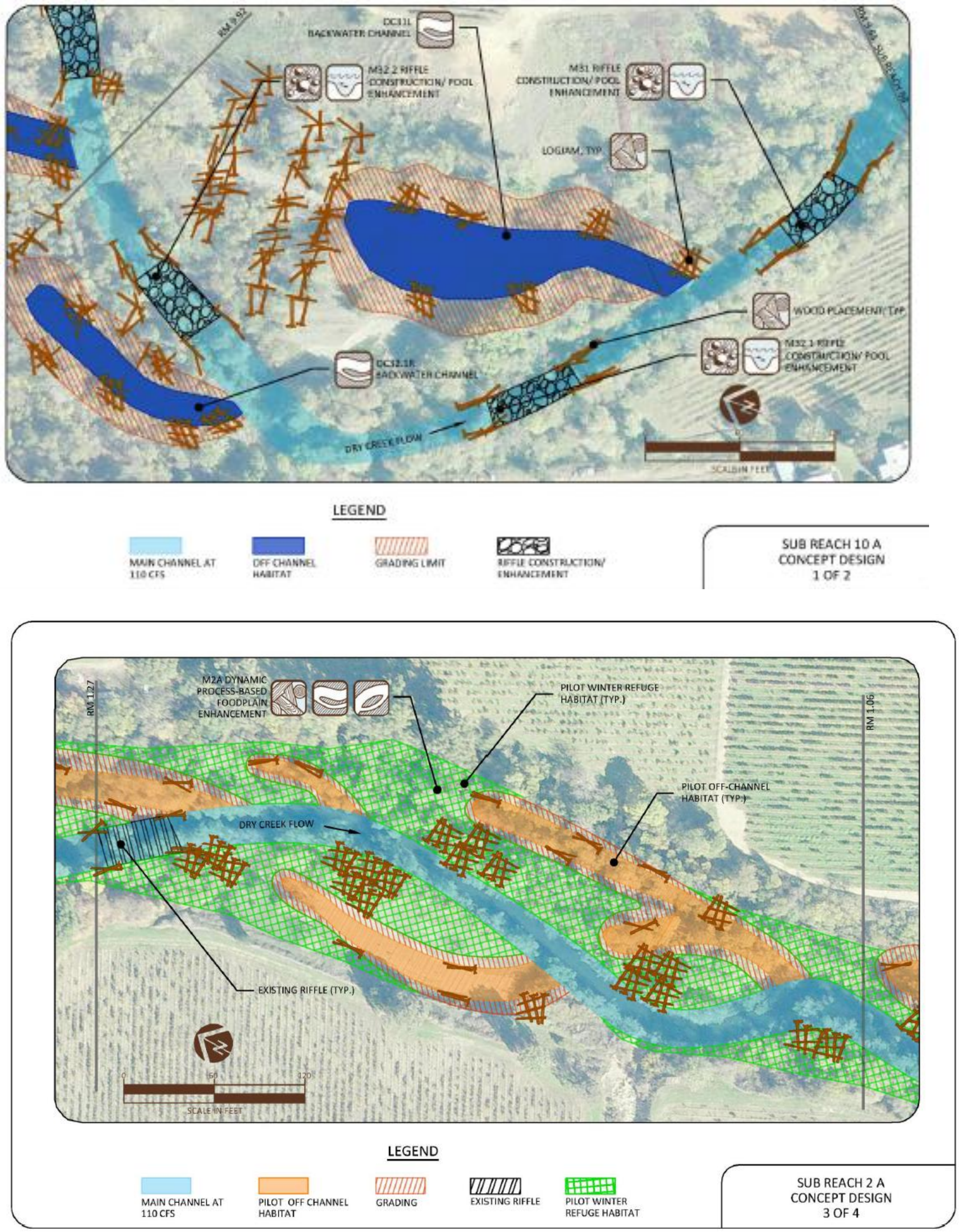


Figure 5.1.2. Examples of habitat enhancement conceptual designs for two Dry Creek subreaches. The top panel, Reach 10A, illustrates proposed summer habitat enhancements using a static "constructed" habitat approach. Reach 2A, lower panel, is close the confluence of Dry Creek and the mainstem Russian River. In this highly dynamic environment, a "process" based approach that creates pilot habitat features the stream can adjust over time is proposed.

Table 5.1.1. Ranking of enhancement subreaches in Dry Creek organized by Upper, Middle, and Lower segments.

Segment	Ranking Tier	(Sub) Reach	Coho Potential Coho Rearing Habitat Score	Winter Refuge & Rearing Habitat Score	Total Potential Habitat Score		Predicted Continuity Score
Upper	Tier I	14a	High	Medium	High		High
		13b	Medium	Medium	Medium		High
		15	Medium	Low	Low		High
		14b	Medium	Low	Low		High
	Tier II	12b	Low	High	Medium		High
		13a	Low	Low	Low		High
		12a	Low	Low	Low		High
Middle	Tier I	8b	High	Medium	High		Medium
		4a	High	Low	High		High
		5a	High	Low	High		Medium
		4b	High	Low	Medium		Medium
		8a	Medium	High	High		High
		5b	Medium	Medium	High		Medium
		10a	Medium	Low	Medium		High
		10b	Medium	Low	Medium		Medium
		4c	Medium	Low	Low		High
	Tier II	6	Low	High	High		Medium
		11	Low	Medium	High		Medium
		9b	Low	Medium	Low		Medium
		9a	Low	Low	Low		Medium
Lower	Tier I	2b	High	High	High		Low
		2a	High	High	High		Low
		1	High	High	High		Low
	Tier II	3b	Medium	Low	Medium		Medium
		3a	Medium	Low	Medium		Medium

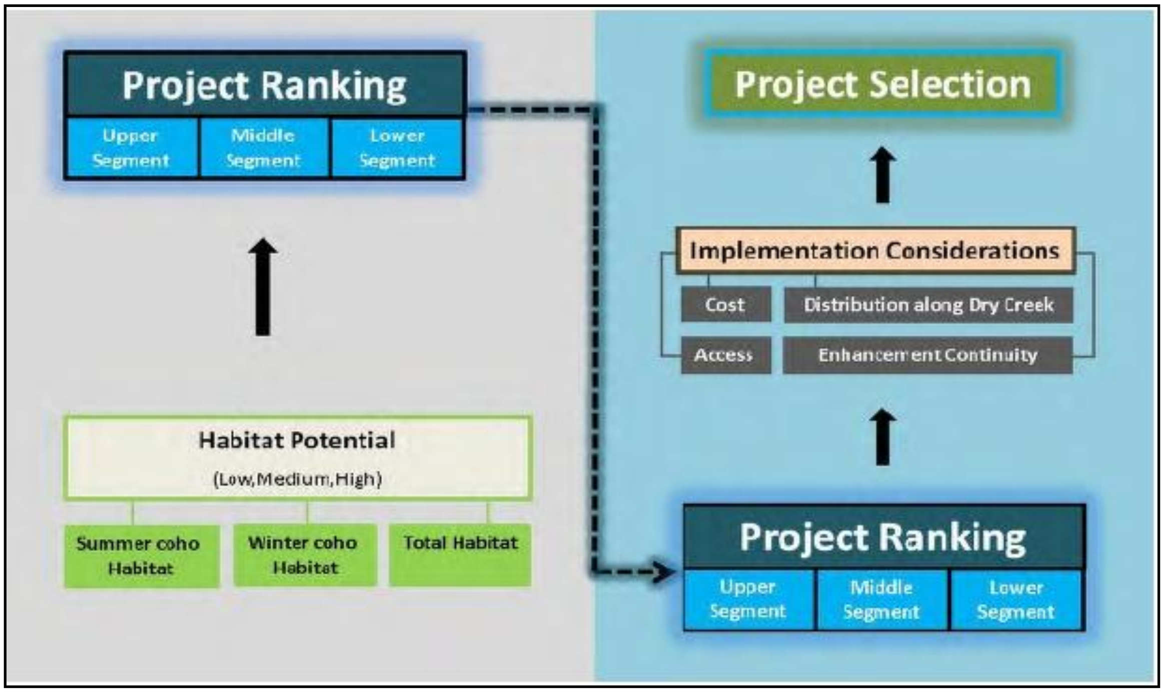


Figure 5.1.3. Conceptual depiction of habitat project prioritization approach. The left side of the figure represents the first phase of the prioritization process which includes ranking of the enhancement subreaches based solely on their inherent potential for habitat enhancement. The second phase, project selection, includes implementation considerations suach as access, distribution, and cost.

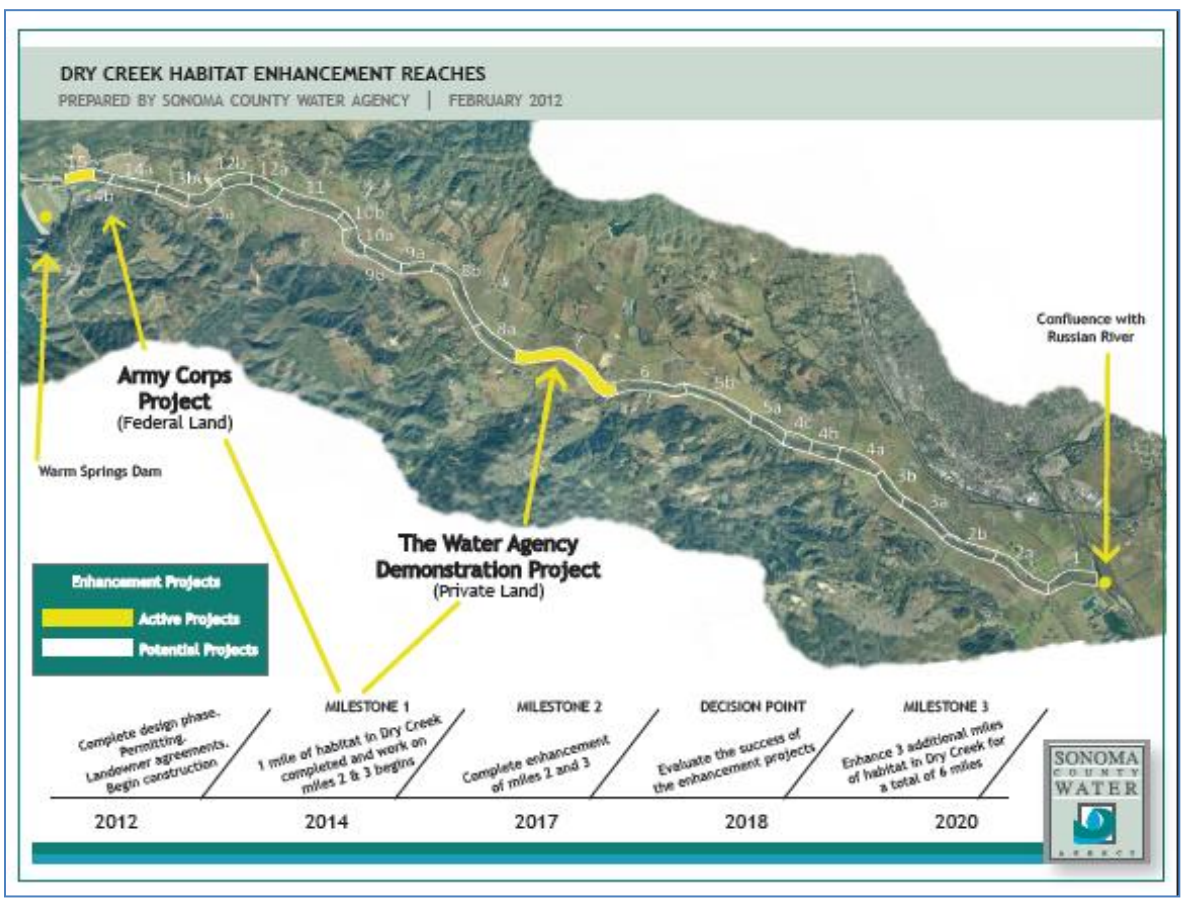


Figure 5.1.4. The location of Water Agency and Army Corps of Engineers Dry Creek habitat enhancement projects to meet Biological opinion milestones.

The U.S. Army Corps of Engineers has implemented a similar habitat enhancement on a 0.3 mile reach of Dry Creek immediately below Warms Springs Dam (Figure 5.1.5 and Photo 5.1.1).

The Demonstration Project has four goals and objectives:

1. Maximize the general ecological lift to the reach to the extent practicable within the current geomorphic and hydraulic function of the stream,
2. Increase the availability of high quality summer rearing and winter refugia habitat for salmonids (specifically coho and steelhead), given the current physical function of the system,
3. Stabilize areas of problem erosion using techniques that also enhance habitat conditions for fish, and
4. Demonstrate enhancement techniques that may be utilized elsewhere in Dry Creek in order to meet the habitat requirements of the Biological Opinion.

In close consultation with NMFS and DFW, InterFluve advanced the Demonstration Project engineering design to the 90 percent complete phase in 2011. A CEQA Initial Study and Mitigated Negative Declaration for the project was approved by the Agency's Board of directors on November 15, 2011. In September 2012, the first phase of the Demonstration Project was constructed by BioEngineering Associates at the Quivira Winery site just downstream of the confluence of Grape Creek and Dry Creek (Figure 5.1.6). This project included the construction of a backwater channel for winter refuge habitat, placement of large wood structures, and removal of invasive plant species (Photo 5.1.2).

In 2013, work on the Demonstration Project continued downstream of Lambert Bridge at the Dry Creek Vineyard and Amista Winery sites. The Water Agency's contractor, Hanford ARC, constructed a large backwater pond for summer and winter habitat, installed boulder clusters and log jams, and implemented a bank stabilization treatment to prevent erosion and enhance habitat (Photos 5.1.3 to 5.1.5).

In 2014, Hanford ARC will continue with the third and final phase of construction of the Demonstration Project. In 2014, Hanford ARC will be working both upstream and downstream of Lambert Bridge on additional backwater ponds and channels, log jams, riffles, and bank stabilization treatments.

Together, the Water Agency's Demonstration Project and the Corps of Engineer's Reach 15 project will provide slightly more than one mile of improved habitat at a total cost of $9 million to $10 million. Pre and Post project data are being gathered and the results of these projects and will be reported in future annual reports.

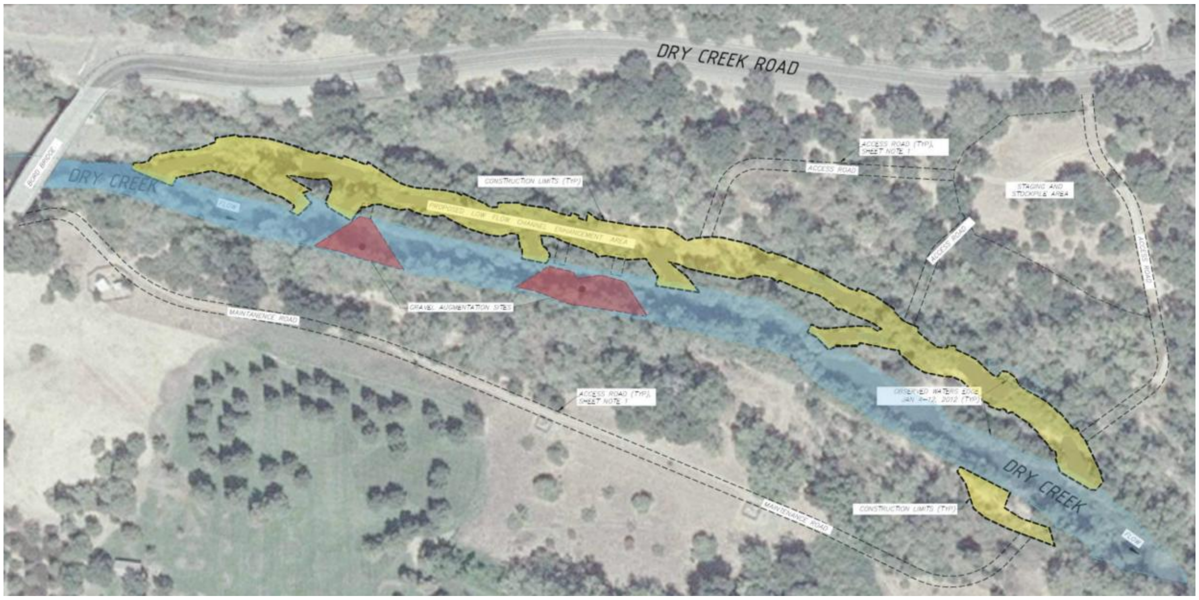


Figure 5.1.5. The Army Corps of Engineers Dry Creek Reach 15 habitat enhancement project. The blue shows the existing flow of Dry Creek. The yellow area shows the side channel area constructed in 2013. The red area shows instream gravel augmentation areas constructed implemented as part of the Reach 15 construction in 2013.

Photo 5.1.1. The Army Corps of Engineers Dry Creek Reach 15 habitat enhancement project.

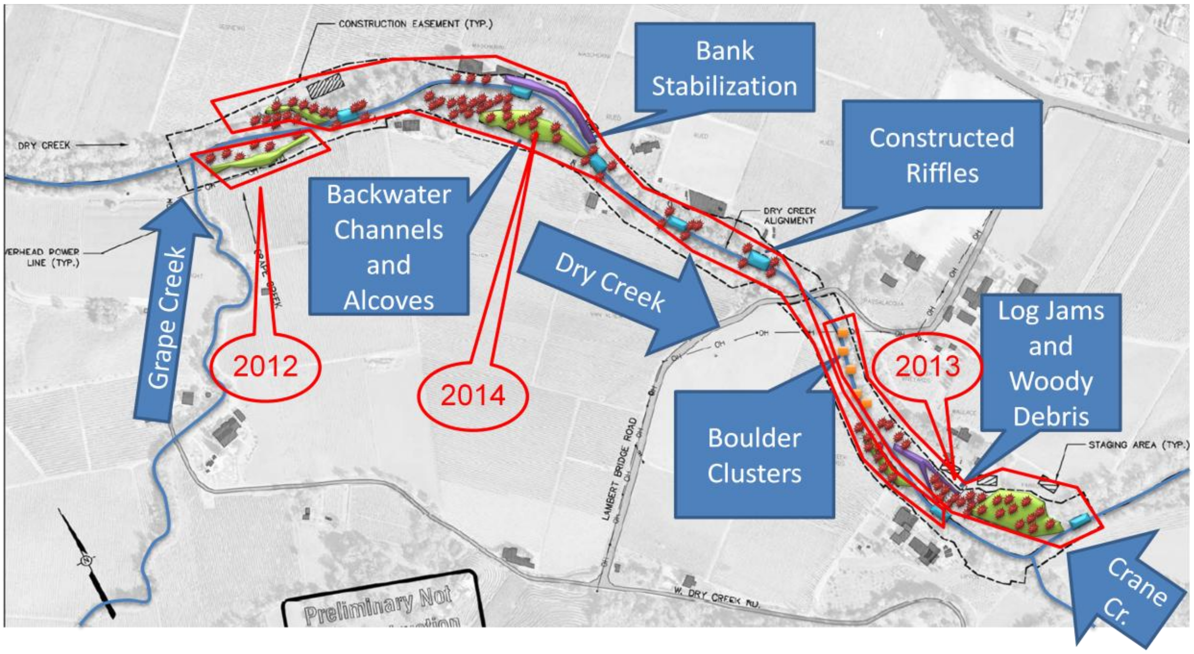


Figure 5.1.6. The Water Agency's Demonstration Project. The blue shows the existing flow of Dry Creek. The red outlines indicate the areas constructed in 2012 and 2013 and the areas scheduled for construction in 2014.

Photo 5.1.2. The Quivira Winery site backwater winter refuge channel constructed in 2012.

Photo 5.1.3. In stream boulder field in Dry Creek downstream of Lambert Bridge installed in 2013.

Photo 5.1.4. Backwater pond area at Amista Winery site downstream of Lambert Bridge. Constructed in 2013.

Photo 5.1.5. Bank stabilization and log jams at Dry Creek Vineyards site downstream of Lambert Bridge. Constructed in 2013.

Miles 2-3

Building on the rankings described above that were developed as part of InterFluve's Dry Creek Fish Habitat Enhancement Conceptual Design Report, the Water Agency has begun outreach to landowners in the upper, middle, and lower segments of Dry Creek as potential sites to make up the next 2 miles of habitat work beyond the Water Agency's Demonstration Project and the Corps of Engineer's Reach 15 project. For the next 2 miles of habitat work, the Water Agency is targeting those sites listed as Tier 1 sites for habitat potential in Dry Creek. The Water Agency is in the process of conducting studies for the CEQA documentation as well as collecting information necessary for developing engineering designs for the Miles 2 and 3 of the Dry Creek habitat enhancement work.

5.2 Validation Monitoring

Part of the Adaptive Management Plan (AMP) for validating the effectiveness of habitat enhancement in mainstem Dry Creek calls for a multiscale monitoring approach in both space and time (Porter et al. 2013). The current section of this report focuses on the results of validation monitoring for juvenile and smolt salmonid populations in mainstem Dry Creek in 2012. These data are part of an ongoing pre-construction (baseline) monitoring effort begun in 2008 and outlined in the Reasonable and Prudent Alternative section of NMFS' Russian River Biological Opinion. Some preliminary effectiveness monitoring data have been collected; however those data will be reported in future reports. Plans for additional effectiveness monitoring are outlined in the AMP.

In the Russian River Biological Opinion status and data report year 2009-10 (Manning and Martini-Lamb 2011), the Water Agency outlined six possible metrics that could be considered for validation monitoring of juvenile salmonids with respect to eventual habitat enhancements in the mainstem of Dry Creek: habitat use, abundance (density), size, survival, growth and fidelity. In 2009-2010, a major focus of validation monitoring in Dry Creek was on evaluating the feasibility of sampling methods to accurately estimate each of those metrics while simultaneously attempting to understand how limitations in sampling approaches may affect our ability to validate project success. These same validation metrics and associated limitations and uncertainties have been discussed in the context of the results of those evaluations and are incorporated into the adaptive management plan described above (Porter et al. 2013). The methods we employed in 2012 are largely based on the outcome of that work (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

In the AMP, three spatial scales of validation monitoring for juvenile salmonids for mainstem Dry Creek have been identified: site/feature, reach, and entire mainstem. The AMP further suggests the appropriate target life stage and temporal scale of monitoring for each spatial scale (Table 5.2.1.2.1). During the current pre-construction monitoring phase, validation monitoring has been at the reach scale in the form of juvenile sampling to estimate size and growth, survival, emigration and population density for steelhead as well as at the stream (mainstem Dry Creek) scale to begin the task of establishing long term smolt population trends for coho salmon. Following project construction, we plan to begin implementing finer spatial scale sampling to estimate use of newly constructed features by juvenile salmonids.

Table 5.2.1. Proposed target life stages, validation metrics, spatio-temporal scale and monitoring tools for validation monitoring in mainstem Dry Creek.

Spatial scale	Target life stage	Target metric(s)	Temporal scale	Primary monitoring tool(s)
Site/feature	Juvenile (non-smolt)	Habitat use, abundance (density), size, growth	Post-construction	Snorkeling, electrofishing, PIT tags and antennas
Reach	Juvenile (non-smolt)	Abundance (density), size, survival, growth, fidelity	Pre-construction (baseline) vs. post-construction	Electrofishing, PIT tags and antennas
Mainstem Dry Creek	Smolt	Abundance	Ongoing to capture long-term trend	Downstream migrant trap, PIT antennas

Methods

Juvenile sampling

In 2012, we continued the focus begun in 2009 and continued in 2010 and 2011 of sampling at the reach scale by making multiple backpack electrofishing passes through relatively long stream sections in an attempt to estimate over-summer survival, emigration and size/growth for juvenile steelhead in the upper, middle and lower reaches of mainstem Dry Creek. As in 2008-2011, we also sampled shorter sections within the middle reach stream section that has been targeted for the first mile of habitat enhancements in mainstem Dry Creek (the “demonstration project”) in order to estimate over-summer growth and population density in early autumn (Figure 5.2.1.2.1). All of the stream sections sampled in 2012 were similar to those sampled in previous years (Figure 5.2.1). Although our primary target species for the eventual habitat enhancement work is coho salmon, steelhead juveniles are also federally threatened in the Russian River and are currently the only salmonid species present in the summer that are abundant enough to estimate the aforementioned parameters in a meaningful way.

Reach-scale sampling

We adopted the geomorphically-based reach designations identified by Inter-Fluve (2011) for our reach-scale sampling. Those reaches are: lower reach (Dry Creek mouth to just downstream of the lowest grade control sill; river km 0.00 to 5.27), middle reach (just downstream of the lowest grade control sill to the confluence of Pena Creek; river km 5.27 to 17.71) and upper reach (river km 17.71 to 22.00).

Reach-scale sampling involved selecting stream sections that could be reasonably sampled with a backpack electrofishing unit. Sampling began by first bounding the downstream end of selected stream sections with a paired PIT antenna array from mid-summer to early autumn, capturing individual juvenile salmonids with a backpack electrofisher and dipnets in late July/early August, PIT-tagging fish that were ≥60 mm and re-sampling the same sections with a backpack electrofisher in each section in late September/early October. Both antenna arrays consisted of two antennas in close proximity to one another so that efficiency for each array could be estimated. For PIT-tagged individuals that were captured in late July then again in autumn (i.e., recaptured), we calculated over-summer growth rates (mm of change in fork length per day). We used the multistate-robust-design model in program MARK (White and Burnham 1999) to estimate over-summer survival and emigration as well as population abundance in early fall by simultaneously estimating the efficiency of each PIT antenna array (Horton et al. 2011). Fall re-sampling actually consisted of two passes through each section. Because these two re-sampling passes were spaced close together in time (2 days apart), we could reasonably assume that survival and emigration probability between these two passes were 1 and 0, respectively. Another important assumption of the multistate-robust-design model is that all fish are equally available for recapture on subsequent sampling occasions; in other words, all fish must remain in the section. If this assumption is violated, section fidelity would remain confounded with true survival meaning that the parameter being estimated would

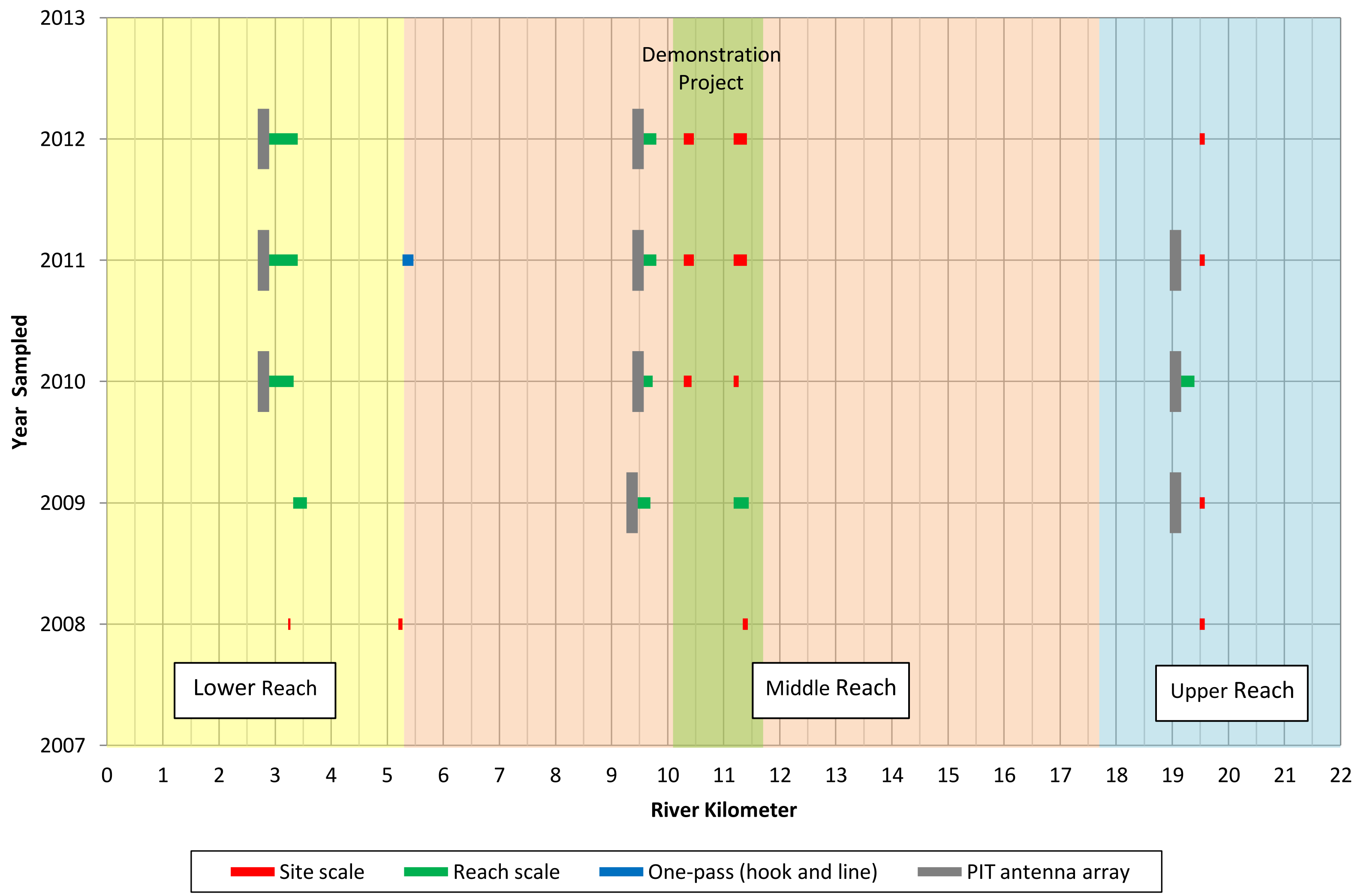


Figure 5.2.1. Years sampled and river kilometer (from the mouth) where juvenile steelhead populations were sampled in mainstem Dry Creek, 2008-2012. Line length for each site is scaled to the length of stream sampled. Data collected at the site scale were analyzed using mark-recapture (either a multiple-pass depletion or Petersen model) and reach scale data collected in 2009 was analyzed with the core-sampling approach (see Manning and Martini-Lamb 2011 for details) while reach scale data collected in 2011-12 were analyzed with the multistate model using program MARK (White and Burnham 1999). The green-shaded area indicates the stream section that has been targeted to receive the first mile of habitat enhancements (the "Demonstration Project").

be apparent survival as opposed to true survival. In order to decouple emigration from mortality paired PIT antenna arrays were located immediately adjacent to the downstream boundary of the stream section sampled so that PIT-tagged fish moving downstream out of the section could be detected. A consequence of this design requirement on Dry Creek, however, was that in particularly deep or swift habitat where the sampling efficacy of backpack electrofishing gear is often low and wading conditions are often unsafe, the choice of contiguous sample sections where PIT antenna arrays could be located at downstream section boundaries was also limited. As a result, we were unable to find a section in the upper reach that was suitable for applying the reach-level sampling possible for the lower and middle reaches. In the middle reach, we sampled a 320 m long section extending from river km 9.48 to 9.80; in the lower reach, we sampled a 526 m long section extending from river km 2.80 to 3.33 (Figure 5.2.1). Within each section, the location of capture for each individual was recorded to the nearest 46 m.

Site-scale sampling

Site-scale sampling involved defining two relatively shorter (270 and 180 m) contiguous sites within the demonstration project area (located in the middle reach of Dry Creek), capturing individual juvenile steelhead with a backpack electrofisher in late July/early August, PIT-tagging fish that were ≥60 mm and re-sampling the same sections in late September/early October followed 2 days later by a recapture pass through each section. We used this same sampling approach on a 93 m long section in the upper reach. For PIT-tagged individuals that were captured in late July then again in autumn, we calculated over-summer growth rates (mm of change in fork length per day). From the paired sampling events in early autumn, we used the Petersen mark recapture model to estimate end of summer abundance at these three sites. Provided recapture probability, mortality and the proportion of fish leaving the section between the marking and recapture events is the same for the marked group as it is for the unmarked group, the abundance estimates from the paired mark and recapture events in early autumn should be unbiased.

Smolt sampling

A rotary screw trap with a 1.5 m diameter cone was anchored to the Westside Road bridge, located 3.3 km upstream from the confluence of Dry Creek and the Russian River. Wooden-frame mesh panels were installed adjacent to the rotary screw trap in order to divert downstream migrating salmonids into the trap that may have otherwise avoided the trap.

Fish handling methods and protocols were similar to those used in previous years (see Manning and Martini-Lamb 2011). Fish captured in the trap were identified to species and enumerated. A subsample of each species was anesthetized and measured for fork length each day, and a subsample of salmonid species was weighed each week. With the exception of up to 50 Chinook salmon smolts each day, all fish were released downstream of the first riffle located downstream of the trap. Each day, up to 50

Chinook smolts (≥60 mm) were finclipped and released approximately 100 m upstream of the trap for the purpose of estimating population abundance using program DARR (Bjorkstedt 2005). Finclipped fish that were recaptured in the trap were noted and released downstream (the lengths and weights of recaptured fish were not recorded a second time).

Results

Juvenile sampling
We captured a total of 15 wild coho YOY during electrofishing sampling in mainstem Dry Creek in 2012. Although the total number was low, fish were found from river km 2.8 to river km 19.5 indicating that they were relatively spread out and probably not from redd(s) in a single location.

Densities of juvenile steelhead in 2012 ranged from less than 0.11 fish/m^2 to 0.17 fish/m^2 (Figure 5.2.2). When averaged for all sites within a year, densities in 2012 were slightly higher (0.01 fish/ m^2) than the four year average from 2009-2012 but lower (0.08 fish/ m^2) than the five year average from 2008-2012 (Figure 5.2.3).

Monthly survival estimates of juvenile steelhead in 2012 was between 0.55 (lower reach) and 0.69 (middle reach) (Figure 5.2.4). Approximately 25% of the fish emigrated from their respective tagging reach (Figure 5.2.5).

The overall mean size of coho salmon YOY captured in 2012 was 80 mm (SD: 12.9). Sample size (n=15) was too low to evaluate the data for differences in mean size among reaches.

Mean individual growth rates of juvenile steelhead in 2012 were significantly lower in the upper reach as compared to the middle and lower reaches (Figure 5.2.6). These data help to explain a similar trend in size data (smaller-sized fish in the upper reach) evident in data from 2008-2010 as well (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

Smolt sampling
We installed the rotary screw trap on April 4 following the recession of high flows. The trap was checked daily during operation from April 4 until it was removed on July 31 (Figure 5.2.7).

The peak capture of Chinook smolts (1,546) occurred during the week of 5/14 (Figure 5.2.8) which was two weeks earlier than in 2011 when the peak occurred the week of 5/28. Based on the estimated average weekly capture efficiency (range: 4% to 34%, Figure 5.2.9 upper panel), the resulting population size of Chinook salmon smolts passing the Dry Creek trap between April 4 and July 30 was 236,344 (±95%CI: 21,568, Figure 5.2.9 lower panel).

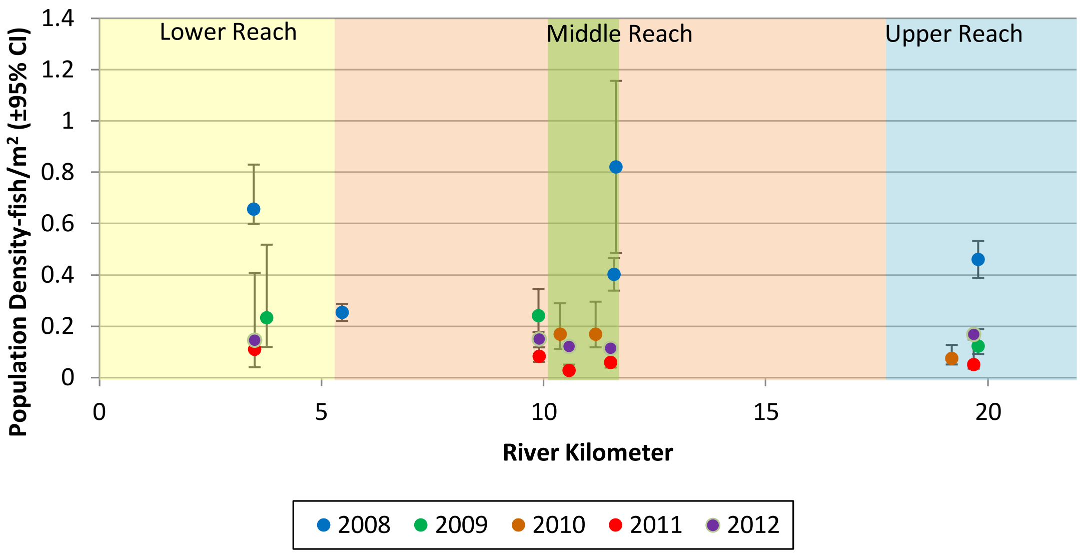


Figure 5.2.2. Estimated density of juvenile steelhead in mainstem Dry Creek, 2008-2011. Estimates are from a variety of approaches all based on mark-recapture models.

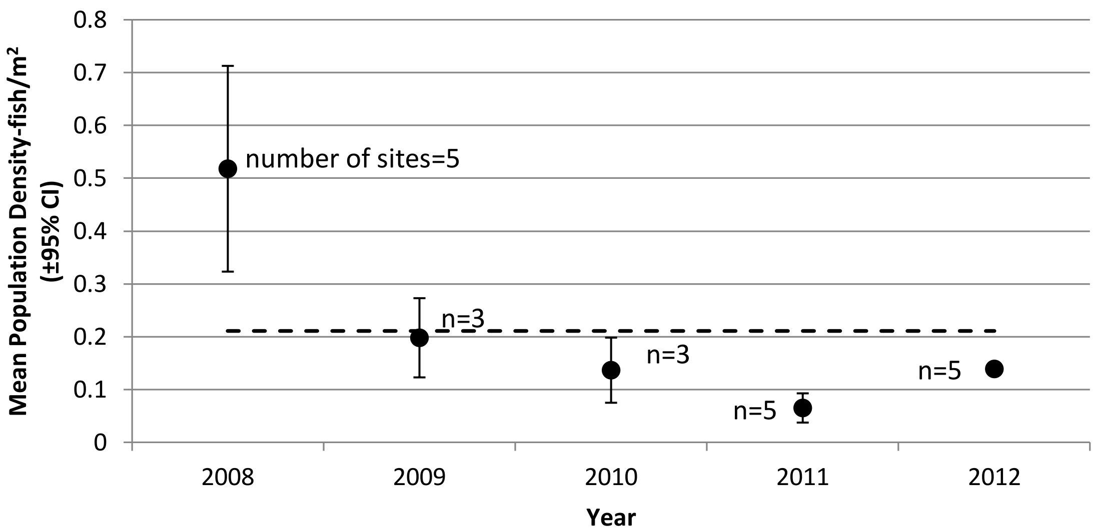


Figure 5.2.3. Mean juvenile steelhead density among all sites sampled within a year in mainstem Dry Creek, 2008-2012. "n" refers to the number of sites sampled. Dashed line is the five year average density.

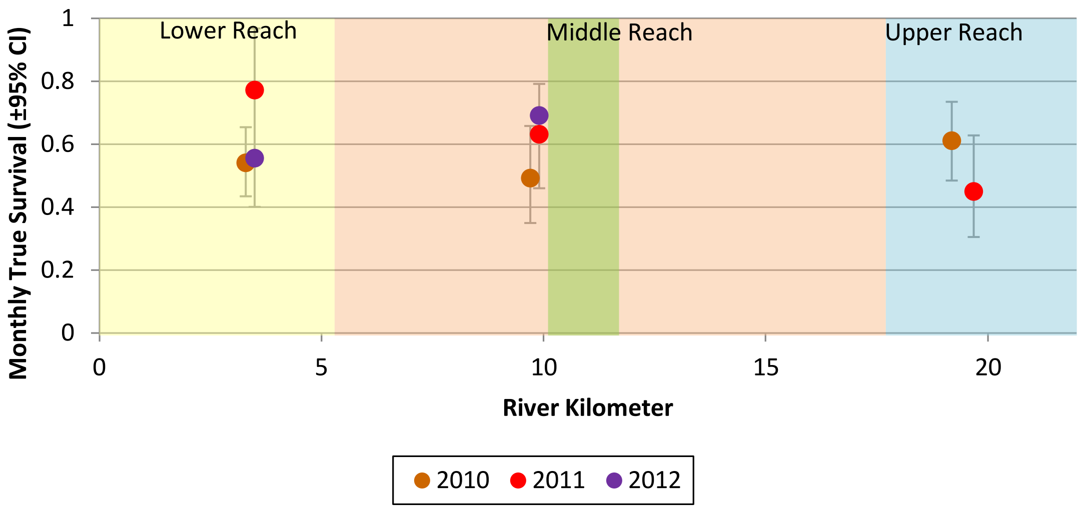


Figure 5.2.4. Estimated monthly true survival of juvenile steelhead from mainstem Dry Creek, 2010-2012.

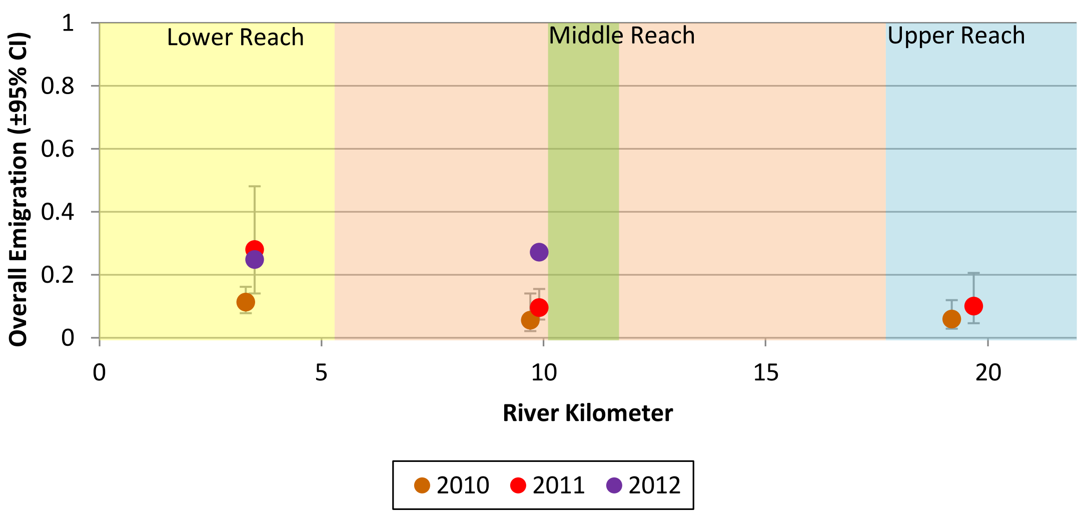


Figure 5.2.5. Estimated overall reach-specific emigration of juvenile steelhead from mainstem Dry Creek, 2010-2012.

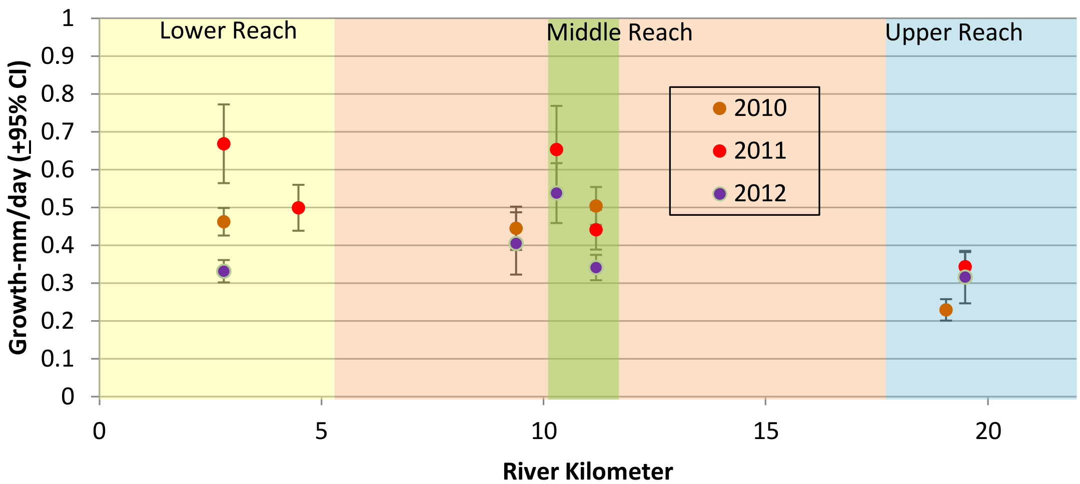


Figure 5.2.6. Estimated growth rates of juvenile steelhead from mainstem Dry Creek, 2012. Estimates are from individual growth rates calculated as the change in fork length (mm) per day of PIT-tagged fish between initial tagging in July and recapture in late September/early October.

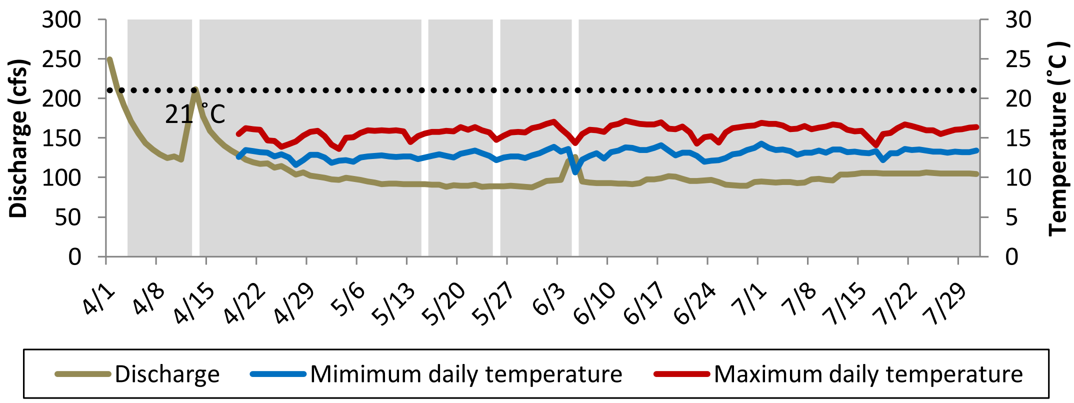


Figure 5.2.7. Discharge (CFS) at Yoakim Bridge (USGS gauge 11465200), and the days the Dry Creek rotary screw trap fished, 2012 (shaded area).

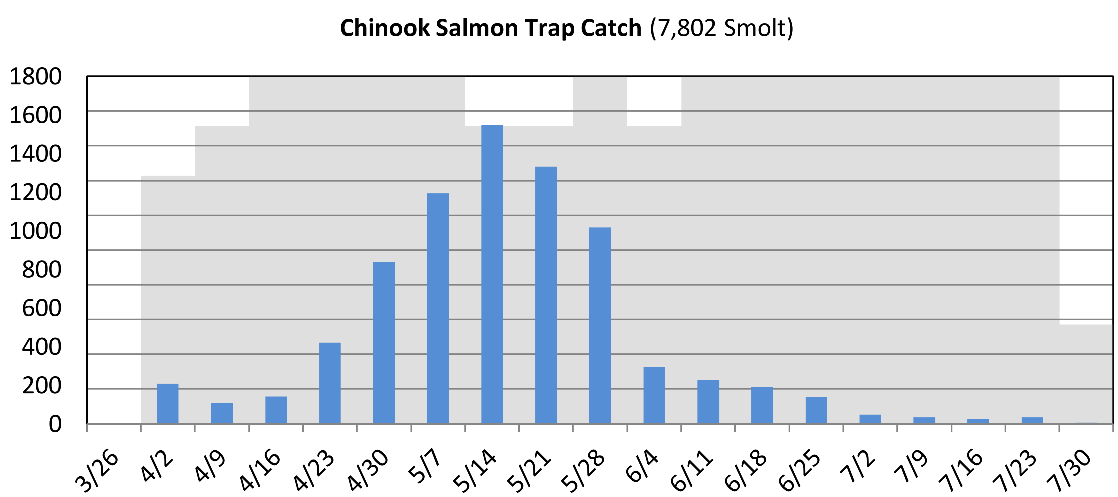
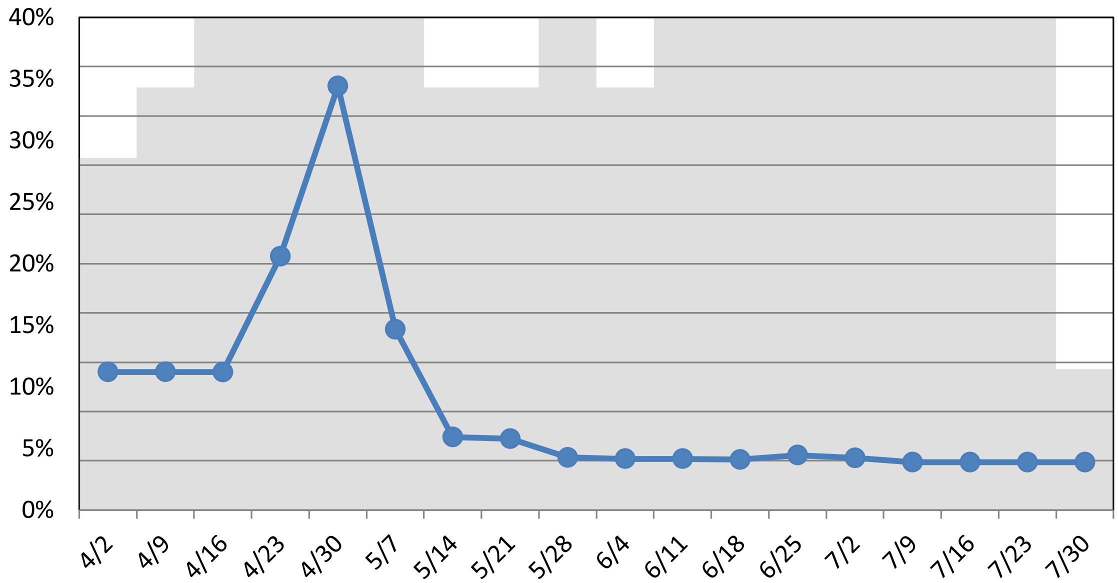


Figure 5.2.8. Weekly trap catch of Chinook salmon smolts in the Dry Creek rotary screw trap and the proportion of each week the trap was fished, 2012 (shaded area).

Chinook Salmon Smolt, Estimated Capture Efficiency (Overall=6.18%)



Chinook Salmon Smolt, Estimated Abundance (Total=236,344 ±95%CI: 21,568

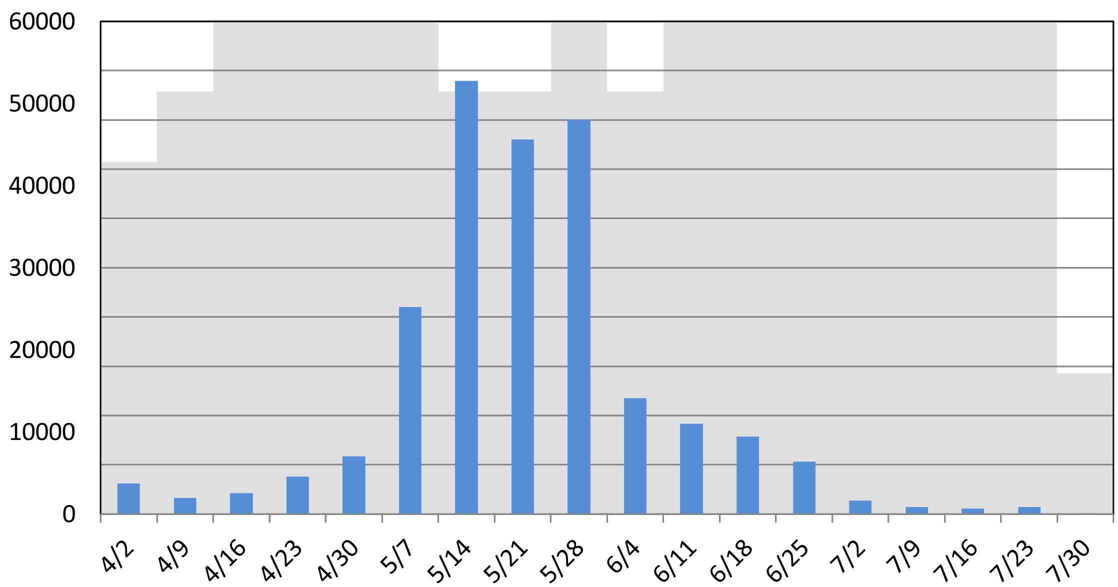


Figure 5.2.9. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap (lower panel), 2012. Estimates are from DARR (Bjorkstedt 2005). The proportion of each week the trap was fished is represented by the shaded area.

The estimated pattern in weekly trap efficiency was similar among the four years of trap operation; however, the overall trap efficiency for the season was lower in 2012 than any of the other years of trap operation. Abundance, however, varied by over 2.5-fold from a low of 84,785 in 2010 to a high of 236,343 in 2012 (Figure 5.2.10).

Coho were the least abundant of the 3 salmonid species captured. Steelhead parr capture peaked in late mid-June with a season total capture of 4,705 individuals (Figure 5.2.11).

The weekly sizes of all salmonids captured at the Dry Creek trap all showed evidence of growth during the course of the trapping season in 2012 (Figure 5.2.12).

Conclusions and Recommendations

The importance of establishing a clear baseline as we move into the habitat enhancement phase of the Dry Creek project cannot be overstated. We recommend continuation of monitoring at the reach-scale (electrofishing/PIT tagging) and stream-scale (downstream migrant trapping) over time so that we can understand whether changes in population metrics are due to eventual habitat enhancements as opposed to natural population variability from external drivers. An added monitoring scale in 2013 and beyond will be sampling at the site/feature scale so that once habitat enhancements are implemented we will be able to evaluate fish responses to those projects in a meaningful way. We expect that PIT tags and PIT antennas along with direct observation through snorkel surveys in newly-created and newly-enhanced reaches will form the basis for that site-scale work. Planned evaluation of secondary metrics such as macroinvertebrate community dynamics and juvenile salmonid diet studies will be important companion data for understanding baseline conditions that currently structure salmonid populations in mainstem Dry Creek.

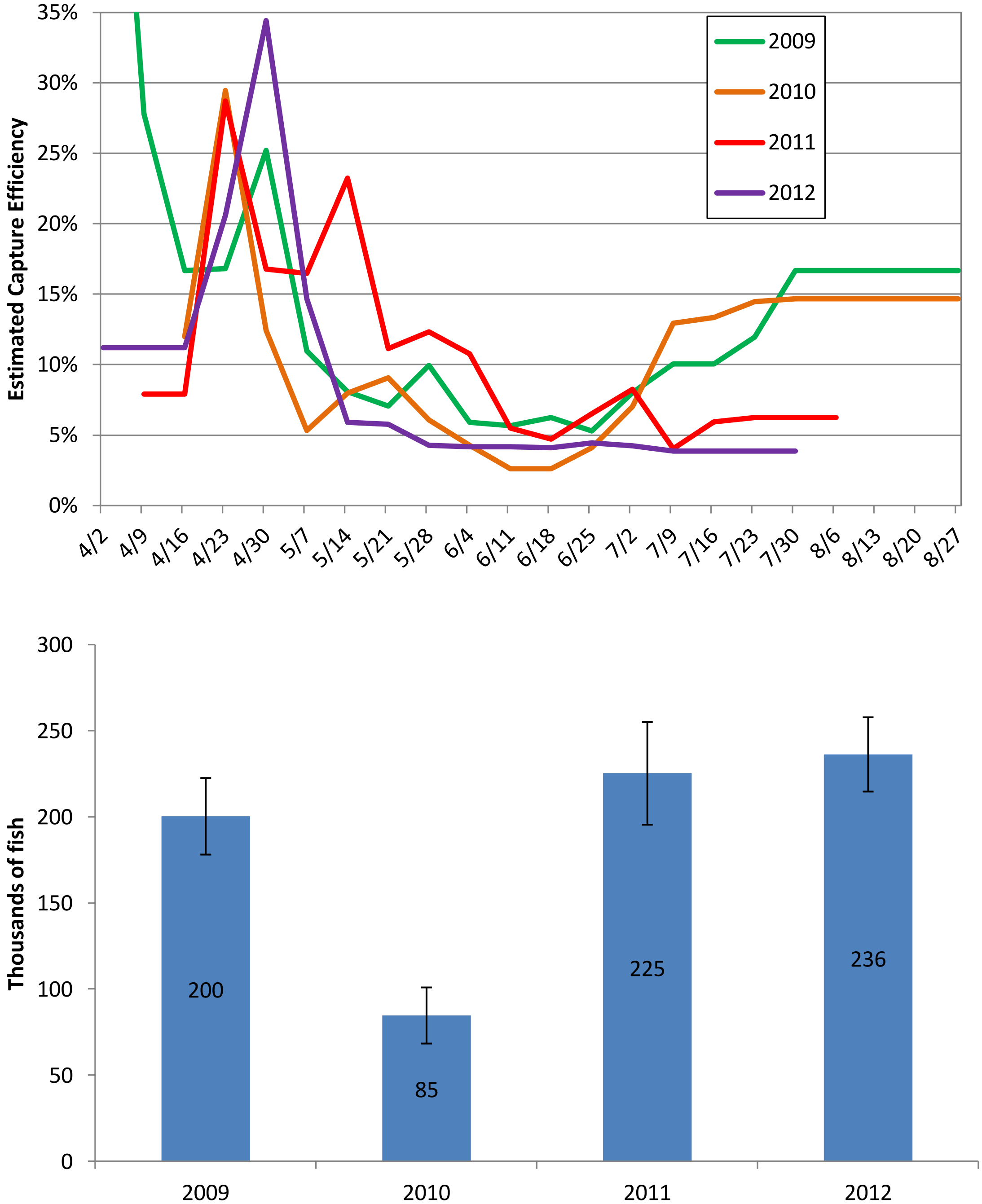
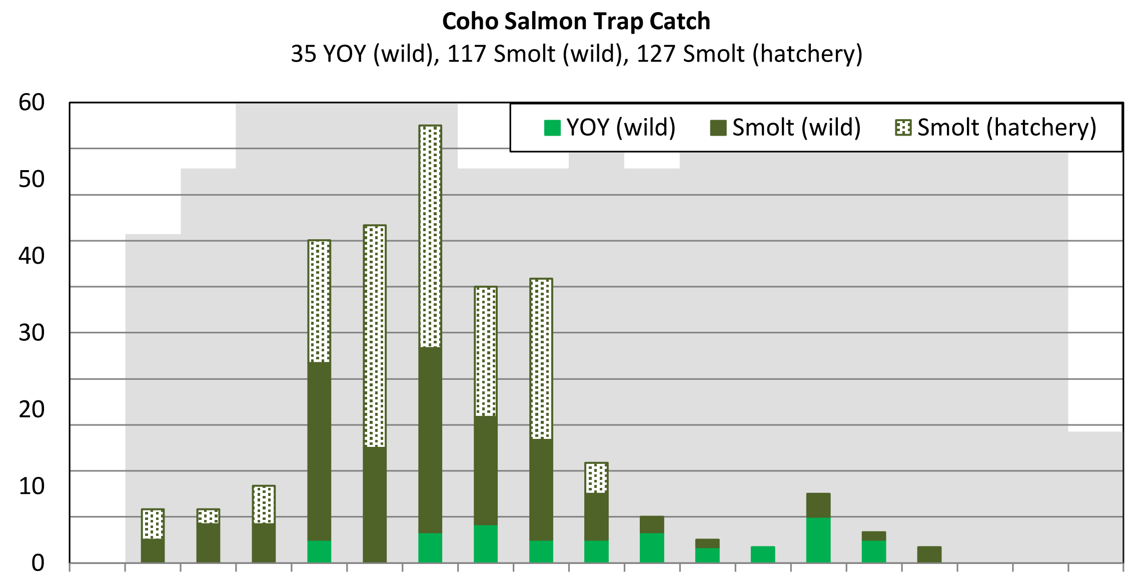


Figure 5.2.10. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook salmon smolts (x1000) produced from the Dry Creek watershed upstream of Westside Road (lower panel), 2009-2012.



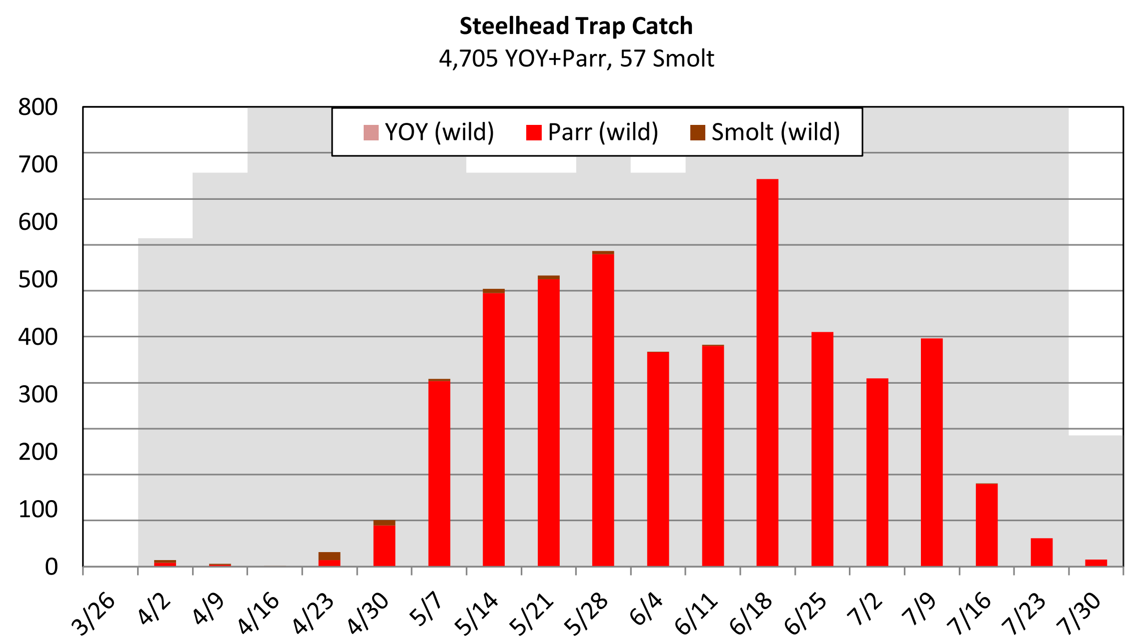


Figure 5.2.11. Weekly trap catch of juvenile coho salmon and steelhead in the Dry Creek rotary screw trap, 2012.

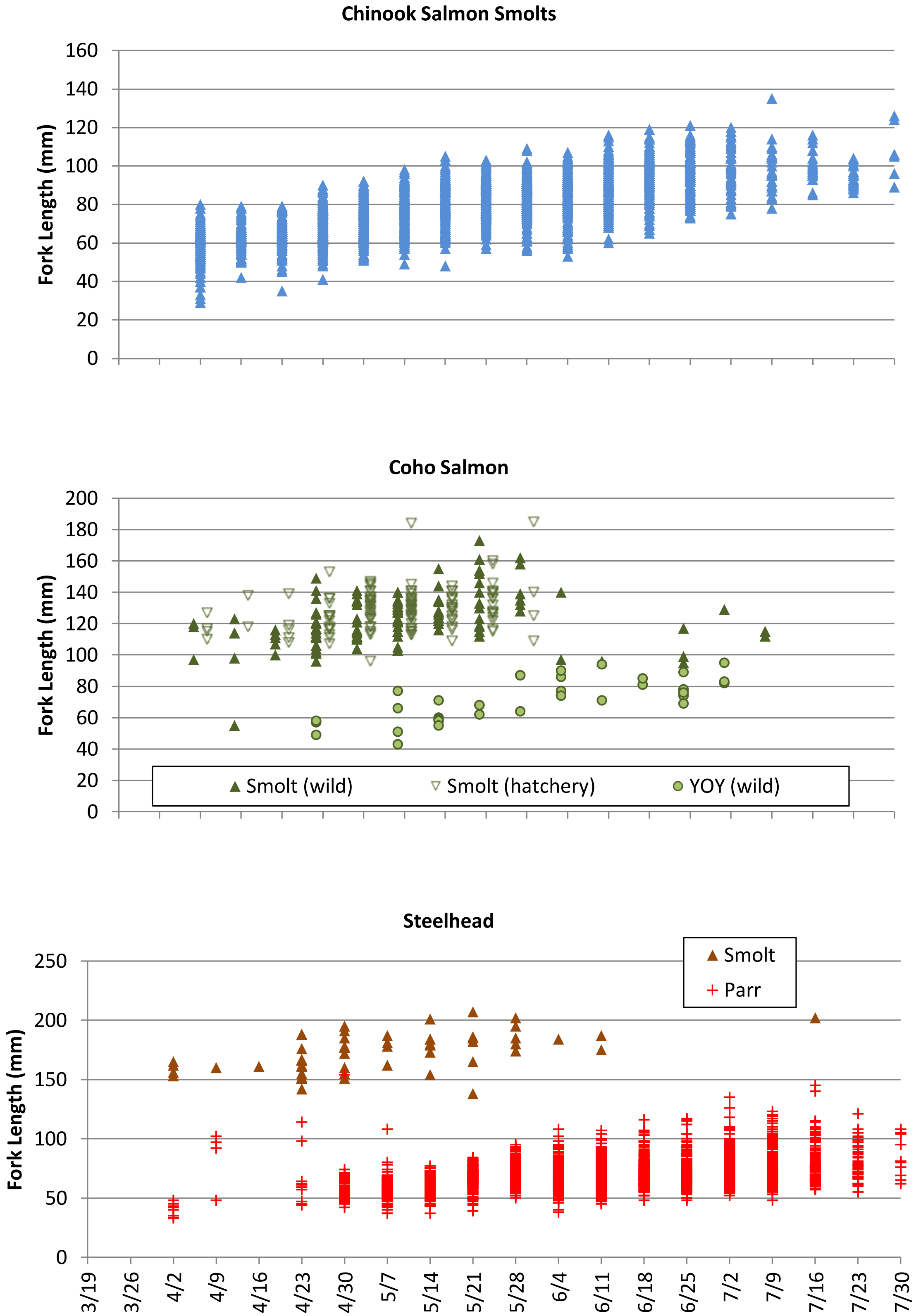


Figure 5.2.12. Fork lengths of juvenile salmonids captured in the Dry Creek rotary screw trap by week, 2012. The solid line

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6: Tributary Habitat Enhancements

One component of the reasonable and prudent alternative (RPA) identified in the Biological Opinion is the enhancement of salmonid rearing habitats in tributaries to Dry Creek and the Russian River. A total of ten potential tributary enhancement projects are listed in the Biological Opinion with the requirement that the Water Agency implement at least five of these projects by the end of year 3 of the 15 year period covered by the Russian River Biological Opinion. The five projects that the Water Agency intended to complete were 1) Grape Creek Habitat Improvement Project; 2) Willow Creek Fish Passage Enhancement Project; 3) Mill Creek Fish Passage Project; 4) Wallace Creek Fish Passage Project; and 5) Grape Creek Fish Passage Project. The Water Agency entered into agreements with the Sotoyome Resource Conservation District, now named Sonoma Resource Conservation District (RCD), to coordinate and implement two of these projects (the Grape Creek Habitat Improvement Project and Mill Creek Fish Passage Project), and with Trout Unlimited to provide funding towards the Willow Creek Fish Passage Enhancement Project. The Water Agency was also coordinating work with the Sonoma County Department of Transportation and Public Works to implement the Wallace Creek and Grape Creek Fish Passage Projects. After efforts to secure landowner access for the Mill Creek Fish Passage Project were unsuccessful, the Water Agency abandoned efforts on the Mill Creek Fish Passage Project and directed the Sotoyome Resource Conservation District to substitute the Crane Creek Fish Passage Project. The Water Agency also amended its agreement with the RCD to allow the RCD to oversee the implementation of the Grape Creek Fish Passage Project. The Wallace Creek Fish Passage Project, again after efforts to secure landowner access were unsuccessful, has been abandoned. The Water Agency is working with the National Marine Fisheries Service on an alternative as a substitute for the Wallace Creek Fish Passage Project.

6.1 Grape Creek Habitat Improvement

Phase 1

The Grape Creek Phase 1 portion of the project consisted of installing 8 complex log and boulder structures along a 1,200 foot reach of Grape Creek upstream of the Wine Creek Road Crossing (Figure 6.1.1). Implementation of this work took place in July and August of 2009. All areas where vegetation was disturbed by heavy equipment were replanted with native plants prescribed by restoration staff from the RCD. Additional plantings were also installed per the request of the California Department of Fish and Wildlife, and permission of the landowner, in areas outside the active construction area in an effort to eventually expand the width of the riparian area. A total of 248 native trees and shrubs were planted along this reach of the project. During 2011, maintenance and weeding of the plantings was conducted. General observations of the log structures during and after high creek flows of 2011-2012 have not shown any

Figure 6.1.1. Grape Creek – Phase 1. In-Stream Large Woody Debris Structure Example

changes or failures in any of the Phase 1 reach structures. The first post-construction monitoring efforts occurred during the summer of 2011 (Figure 6.1.2). Riparian plantings were monitoring and maintained in 2012 (Figure 6.1.3). Follow-up post-construction monitoring efforts were conducted during the summer of 2013.

Figure 6.1.2. Grape Creek – Phase 1. 2011 Post-Construction Monitoring

Figure 6.1.3. Grape Creek – Phase 1. February 2012.

Phase 2

The Grape Creek Phase 2 portion of the project consisted of installing 9 complex log and boulder structures and 2 bank layback areas along a 700 foot reach of Grape Creek upstream of the West Dry Creek Road Crossing (Figure 6.1.4). Implementation of this work took place over two construction seasons, in 2009 and 2010. Construction began in early October 2009 and was cut short due to rain. Revegetation took place in January 2010. In February 2010, portions of one structure (Site 5) were removed as an emergency measure to avoid bank erosion on the opposite bank as a result of the structure's movement during high flows. Construction resumed in late August 2010, with heavy equipment work completed in the first week of September, and final touches placed on erosion control in early October. The remaining vegetation was installed in early 2011 when the soil is sufficiently moist. General observations of the log structures during and after high creek flows of 2011-2012 have not shown any changes or failures in any of the Phase 2 reach structures. The first post-construction monitoring efforts occurred during the summer of 2011 (Figure 6.1.5). Riparian plantings were monitoring and maintained in 2012 (Figures 6.1.6 and 6.1.7). Follow-up post-construction monitoring efforts were conducted during the summer of 2013.

Figure 6.1.4. Grape Creek – Phase 2. Large Woody Debris and Bank Layback Example.

Figure 6.1.5. Grape Creek – Phase 2. 2011 Post-Construction Monitoring.

Figure 6.1.6. Grape Creek – Phase 2. February 2012.

Figure 6.1.7. Grape Creek – Phase 2. February 2012.

6.2 Willow Creek Fish Passage Enhancement Project

Willow Creek is a tributary to the lower Russian River that once supported an abundant subpopulation of coho salmon. The creek continues to support significant potential spawning and rearing habitat; however, access to that habitat is blocked by impassable road culverts and a shallow braided channel that passes through forested wetland. To implement the Willow Creek Fish Passage Enhancement Project, the Water Agency contributed $100,000 in funding to Trout Unlimited towards the removal of a complete barrier in Willow Creek. On October 19, 2010, the Water Agency's Board of Directors approved the funding agreement with Trout Unlimited for the Willow Creek Fish Passage Enhancement Project. The $100,000 in funding was provided by the Water Agency to Trout Unlimited on January 26, 2011. During the summer of 2011, construction was completed for the Willow Creek Fish Passage Enhancement Project (Figures 6.2.1 and 6.2.2).

Figure 6.2.1. Willow Creek Bridge Installation. September 2011.

Figure 6.2.2. Willow Creek Bridge Installation. September 2011.

6.3 Crane Creek Fish Passage Project

The Water Agency originally intended to implement the Mill Creek Fish Passage Project. The Mill Creek Fish Passage Project required landowner permission from two property owners in order to design and construct the project. One of the property owners was willing to enter into an agreement to allow the project to move forward; however, the second landowner gave multiple indications that they would allow the project to move forward, but ultimately failed to ever sign any access agreements to allow project design to move forward. Multiple attempts at obtaining the bneccessary permissions from this landowner were made by the Stoyome Resource Conservation District and the National Marine Fisheries Service. Still seeing no progress with this landowner, the Water Agency directed the Sotoyome Resource Conservation District in December 2010 to abondon its efforts on the Mill Creek Fish Passage Project and instead implement the Crane Creek Fish Passage Access Project (Figure 6.3.1). The Crane Creek Fish Passage Access Project consists of the removal of a barrier to fish passgae caused by a bedrock outrcropping at the lower end of Crane Creek near its confluence with Dry Creek (Figure 6.3.2). The proposed project design developed by Prunuske Chatham, Inc., consists of creating a series of step pools through the bedrock outrcropping to create sufficient depth and flow to allow fish passage (Figure 6.3.3).

Figure 6.3.1. Crane Creek Fish Passage Access Project. Bedrock outcropping.

Figure 6.3.2. Crane Creek Fish Passage Access Project. Chiseling pools in bedrock outcropping.

Figure 6.3.3. Crane Creek Fish Passage Access Project. Expanded pools in bedrock outcropping (February 2012).

Design approval was obtained from National Marine Fisheries Service and the landowners in September of 2011. Construction began on October 1, 2011 and was completed on October 18, 2011.

6.4 Grape Creek Fish Passage Project

The Grape Creek Fish Passage Project consists of the modification of a concrete box culvert where Grape Creek flows under West Dry Creek Road (Figure 6.4.1). As part of the permit review and design approval process, the National Marine Fisheries Service noted that the project design did not meet their maximum allowable 0.5-foot drop height for barrier passage. In October 2010, the Water Agency proposed re-designing the project to cut into the culvert bottom instead of placing curbs on top of the culvert bottom in order to meet the 0.5-foot maximum drop height requirement. Because the culvert-bottom is a structural portion of the bridge and culvert, cutting into the culvert bottom substantially increases the design complexity and costs of implementing the project. Between October 2010 and March 2011, the Water Agency coordinated with the Sonoma County Department of Public Works on the proposed re-design of the project. In April 2011, National Marine Fisheries Service indicated that the proposed re-design provided by the Sonoma County Department of Public Works was acceptable. Because of the increased complexity and cost, the revised project design was required to be put out to bid as a general construction contract, which required detailed project drawings and construction specifications. The Water Agency worked with a consultant through the Sotoyome Resource Conservation District to prepare the project construction drawings and specifications. Construction of the Grape Creek Fish Passage Project was completed in October of 2012 (Figures 6.4.2 and 6.4.3).

Figure 6.4.1. Grape Creek Fish Passage Project – Flat culvert invert proposed for modification.

Figure 6.4.2. Grape Creek Fish Passage Project – Newly Constructed October 2012.

Figure 6.4.3. Grape Creek Fish Passage Project – First Flows November-December 2012.

6.5 Wallace Creek Fish Passage Project

Wallace Creek Fish Passage Project consists of the modification of a concrete box culvert where Wallace Creek flows under Mill Creek Road (Figure 6.5.1). Engineering designs were completed and the National Marine Fisheries Service had approved those engineering designs for the project. The County of Sonoma Permit and Resource Management Department had submitted permit applications and coordinated site visits with California Department of Fish and Wildlife, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the North Coast Regional Water Quality Control Board. Unfortunately, the Water Agency has been unable to secure the necessary landowner permissions from two of the three landowners in the project area. Because of the inability to secure the necessary landowner permission for the project, the Water Agency has abandoned efforts to construct the Wallace Creek Fish Passage Project and is working with the National Marine Fisheries Service on an alternative as a substitute for the Wallace Creek Fish Passage Project.

Figure 6.5.1. Wallace Creek Fish Passage Project – Flat culvert invert proposed for modification.

7: Coho Salmon Broodstock Program Enhancement

The Biological Opinion and Consistency Determination require the Water Agency to increase production of coho salmon smolts from the Russian River Coho Salmon Broodstock Hatchery Program (Coho Program). The Coho Program is located at the Don Clausen Fish Facility (Warm Springs Hatchery) at the base of Lake Sonoma on Dry Creek. Initiated in 2001, this innovate program is a multi-partner effort involving USACE, CDFW, NMFS, University of California Cooperative Extension (UCCE)/California Sea Grant (CSG), and the Sonoma County Water Agency (SCWA). Native Russian River coho salmon and neighboring Lagunitas (Lagunitas and Olema) Creek coho salmon stock are bred according to a genetic matrix (provided by NMFS Southwest Fisheries Science Center) and progeny are released to more than 20 streams in the Russian River watershed. Fish are released in spring as fry, in fall as fingerlings, and during winter and early spring as smolts. The Biological Opinion requires USACE to fund most hatchery operations and monitoring, but also requires the Water Agency to provide resources to CDFW to produce a minimum of 10,000 coho smolts for release directly into Dry Creek.

The Water Agency purchased 15 tanks for the Coho Program In spring 2010 and they were installed by USACE in fall 2010. These tanks were operational by January of 2011, and have since been used to increase space for juvenile rearing, as well as for holding adult returns, and for the streamside imprinting tanks used on Dutch Bill Creek and Green Valley Creek. The Water Agency also hired a technician in spring 2010 and she has been working full time at the hatchery since the summer of 2010. The technician's primary duties at the hatchery include assisting the Coho Program Biologists with seasonal inventories of Broodstock. Starting in the summer of 2013 she began managing teams of SCWA program assistants on special projects; such as spawning, rearing, tagging and release of all coho salmon progeny.

In the spring of 2012 and 2013, the Coho Program continued with its successful streamside-imprinting tanks and smolt releases to imprint hatchery raised smolts on water in their release tributaries. The Water Agency's senior technician played a principal role in developing and implementing streamside-imprinting techniques. One such special project was a cooperative assignment with a USACE employee in which an imprinting tank was fabricated and installed at Westminster Woods on Dutch Bill Creek. In the spring of 2012 another imprinting tank was fabricated and installed at the Green Valley Village property on Green Valley Creek. These tanks used pumps to circulate creek water through the tank, and were used to hold three to four groups of approximately 2,000 coho smolts for three to four weeks at a time, allowing them time to imprint on the water of their release streams. The technician has also taken the lead on all PIT tagging efforts for the last two seasons. The technician also assists the lead biologist with data processing and annual report writing. The 2012-2013 release summary for Coho Program smolts includes more than 24,000 fish for release into Dry Creek (Table 7.1).

Table 7.1. Russian River Coho Program 2012-13 smolt releases (B. White, USACE, personal communication).

Release Date	Release Stream	# Released	Ave Fork Length (mm)	Ave Weight (g)	Tagging/Release Strategy
6/12/2012	Grape Creek	1,017	66 ± 6	3.4 ± 1.2	100% PIT-tag only
6/13/2012	Dutch Bill Creek	1,045	66 ± 7	3.6 ± 1.6	100% PIT-tag only
6/13/2012	Green Valley Creek	869	69 ± 7	4.1 ± 1.5	100% PIT-tag only
6/14/2012	Thompson Creek	2,045	72 ± 9	4.6 ± 2.2	CWT + 20% PIT (409 PIT)
6/14/2012	Devil Creek	2,239	70 ± 8	4.4 ± 1.8	CWT + 20% PIT (442 PIT)
6/18/2012	Gilliam Creek	4,047	70 ± 8	4.3 ± 1.6	CWT + 20% PIT (810 PIT)
6/19/2012	Gray Creek	5,012	71 ± 8	4.6 ± 1.8	CWT + 20% PIT (1,000 PIT)
6/19/2012	Mill Creek	1,032	65 ± 6	3.3 ± 1.0	PIT-tag only
6/20/2012	Black Rock Creek	6,045	70 ± 8	4.3 ± 1.7	CWT + 20% PIT (1,198 PIT)
6/21/2012	Palmer Creek	7,045	73 ± 9	4.7 ± 1.9	CWT + 20% (1,400 PIT)
	2012 Spring Release Total:	***30,396***			
10/24/2012	Mill Creek	16,040	95 ± 12	11.0 ± 4.5	CWT + 20% PIT (3,225 PIT)
10/25-10/26/2012	Mark West Creek	17,193	96 ± 8	10.9 ± 2.8	CWT only
10/29/2012	Porter Creek (MW)	400	100 ± 9	11.8 ± 3.5	CWT only
	Mark West Creek	2,582			
10/31/2012	Pena Creek	7,015	100 ± 11	12.7 ± 4.6	CWT + 20% PIT (1,396 PIT)
11/1/2012	Porter Creek (RR)	10,198	97 ± 11	11.4 ± 3.2	CWT only
11/5/2012	Sheephouse Creek	3,219	94 ± 9	10.1 ± 2.8	CWT only

11/5/2012	Freezeout Creek	3,193	98 ± 10	12.1 ± 4.0	CWT only
11/6/2012	Purrington Creek	3,004	99 ± 11	12.0 ± 4.2	CWT + 20% PIT (601 PIT)
11/7/2012	Green Valley Creek	10,035	97 ± 12	11.8 ± 4.5	CWT + 20% PIT (1,993 PIT)
11/8/2012	Walker Creek (Marin)	10,835	91 ± 6	8.5 ± 1.8	CWT only
11/13/2012	Dutch Bill Creek	10,038	99 ± 12	12.5 ± 4.7	CWT + 20% PIT (1,986 PIT)
11/14-11/15/2012	Willow Creek	22,151	100 ± 12	12.8 ± 4.8	CWT + 20% PIT (4,381 PIT)
11/19/2012	Grape Creek	2,995	98 ± 9	11.9 ± 3.3	CWT + 20% PIT (597 PIT)
	2012 Fall Release Total:	***118,898***			
3/6/2013	Dry Creek Grp 1	8,408	112 ± 8	17.0 ± 3.7	CWT + PIT
3/22/2013	Dry Creek Grp 2	8,205	116 ± 10	18.7 ± 4.9	CWT + PIT
4/5/2013	Dry Creek Grp 3	8,176	120 ± 13	20.1 ± 5.2	CWT + PIT
	Dry Creek Total	**24,789**			
4/8/2013	**Mill Creek Total**	**6,977**	113 ± 10	17.4 ± 4.7	CWT + PIT; put in pond on 3/18/13, 21 days imprinted
4/11/2013	Dutch Bill Creek Grp 1	1,881	111 ± 9	17.8 ± 4.6	CWT + PIT; put in tank on 3/20/13, 22 days imprinted
4/30/2013	Dutch Bill Creek Grp 2	2,093	121 ± 8	20.5 ± 4.1	CWT + PIT; put in tank on 4/12/13, 18 days imprinted
5/21/2013	Dutch Bill Creek Grp 3*	2,089	123 ± 10	21.0 ± 5.0	CWT + PIT; put in tank on 5/1/13, 20 days imprinted
	Dutch Bill Creek Total	**6,063**			
4/16/2013	Green Valley Creek Grp 1	1,507	112 ± 7	17.6 ± 3.3	CWT + PIT; put in tank on 4/2/13, 14 days imprinted
5/1/2013	Green Valley Creek Grp 2	1,499	118 ± 11	20.0 ± 5.4	CWT + PIT; put in tank on 4/18/13, 13 days imprinted
5/14/2013	Green Valley Creek Grp 3	1,572	127 ± 9	22.9 ± 5.4	CWT + PIT; put in tank on 5/2/13, 12 days imprinted

5/28/2013	Green Valley Creek Grp 4*	1,504	128 ± 9	24.0 ± 5.5	CWT + PIT; put in tank on 5/15/13, 13 days imprinted
	Green Valley Creek Total	**6,082**			
	2013 Smolt Release Total:	***43,911***			
	2012-13 Release Total:	***193,205***			

* Released into the mainstem of the Russian River near the confluence of release stream due to low flow conditions.

8: Wohler-Mirabel Water Diversion Facility

The Water Agency diverts water from the Russian River to meet residential and municipal demands. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. The Water Agency's water diversion facilities are located near Mirabel and Wohler Road in Forestville. The Water Agency operates six Ranney collector wells (large groundwater pumps) adjacent to the Russian River that extract water from the aquifer beneath the streambed. The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed. To augment this rate of recharge, the Water Agency has constructed several infiltration ponds. The Mirabel Inflatable Dam (Inflatable Dam) raises the water level and allows pumping to a series of canals that feed infiltration ponds located at the Mirabel facility. The backwater created by the Inflatable Dam also raises the upstream water level and submerges a larger streambed area along the river. Three collectors wells, including the Agency's newest and highest capacity well, are located upstream of Wohler Bridge. These wells benefit substantially from the backwater behind the Dam.

8.1 Mirabel Fish Screen and Ladder Replacement

To divert surface water from the forebay of Mirabel Dam, The Water Agency operates a pump station on the west bank of the river. The pump station is capable of withdrawing 100 cfs of surface flow through two rotating drum fish screens in the forebay. The fish screens have been functioning since the dam was constructed in the late 1970s. However, they fail to meet current velocity standards established by NMFS and CDFW to protect juvenile fish. The Biological Opinion requires the Water Agency to replace the antiquated fish screens with a structure that meets modern screening criteria. In 2009, the Water Agency employed the engineering firm of Prunuske Chatham, Inc. to prepare a fish screen design feasibility study. The report was completed in December 2009.

The feasibility study was conducted to develop a preferred conceptual design that meets many of the project objectives while ensuring that the fish screening facilities adhere to contemporary fish screening design criteria. A Technical Advisory Committee composed of the Water Agency engineering and fisheries biologist staff, NMFS, and CDFW provided guidance in refining the objectives and identifying alternatives. Six concept alternatives were evaluated for meeting the project objectives. Schematic designs and critical details were developed for these concept alternatives to assess physical feasibility and evaluate alternatives relative to the objectives. The preferred concept design alternative was determined through an interactive evaluation and was selected because it meets or exceeds the project objectives.

In 2010, the Water Agency solicited qualifications from engineering firms, and a list of qualified consultants was created from the responses. The Water Agency selected HDR Engineering (HDR) because of its demonstrated experience with this type of work and the strength of their proposed project manager, who has a proven track record with fish passage and screening projects. The Water Agency and HDR entered into an Agreement for Engineering Design Services for the Mirabel Fish Screen and Fish Ladder Replacement Project in June of 2011. In 2011 and 2012, HDR completed work on preliminary engineering, geotechnical analysis, hydraulic modeling, development of construction drawings and specifications. HDR's final construction drawings and specifications are anticipated in December 2013. HDR will also provide engineering support during bidding and construction. HDR's design process included consultation at different design steps with the Technical Advisory Committee described above.

Because the fish ladder enhancement identified in the feasibility study is not required by the Biological Opinion, the Water Agency applied for funds from CDFW's Fishery Restoration Grant Program (FRGP) in 2010 to help defray costs associated with fish ladder design. The Director of CDFW awarded the grant to the Water Agency in February 2011. The Water Agency also submitted a second application for FRGP funds in 2012 to help defray costs associated with fish ladder construction. The Director of CDFW awarded the grant to the Water Agency in February 2013.

The Water Agency has completed the California Environmental Quality Act (CEQA) documentation for the project. On December 10, 2012, the Water Agency released for public review an Initial Study and Mitigated Negative Declaration for the Mirabel Fish Screen and Fish Ladder Replacement Project. This document was available for public review through January 18, 2013 and was then brought before the Water Agency's Board of Directors for their consideration on January 29, 2013 where the Board of Directors approved the Initial Study and Mitigated Negative Declaration of Environmental Impact for the Project and approved the Project. Water Agency staff filed a Notice of Determination under CEQA for the project on January 29, 2013.

The CEQA document for the project included a discussion of potential environmental impacts related to the construction, operation, and maintenance of the proposed fish screen and fish ladder modifications. Project construction activities will require isolating the work area from the active flow of the Russian River, demolishing the existing fish screen/intake and fish ladder structures on the western bank of the Russian River, and constructing the new fish screen and fish ladder structures. The new facilities will extend approximately 40 feet farther upstream and approximately 100 feet farther downstream than the existing facilities. This larger footprint is necessary to meet contemporary fish screen and fish passage design criteria. Figure 8.1.1 shows a plan view of the proposed project design. Figure 8.1.2 shows a conceptual design drawing of the proposed project components.

Water Agency staff is working with CDFW, the North Coast Regional Water Quality Control Board, and the U.S. Army Corps of Engineers to obtain the permits for construction of the facilities. The first component of the project will be seismic ground improvements made to the levee area to help stabilize the ground material in the project

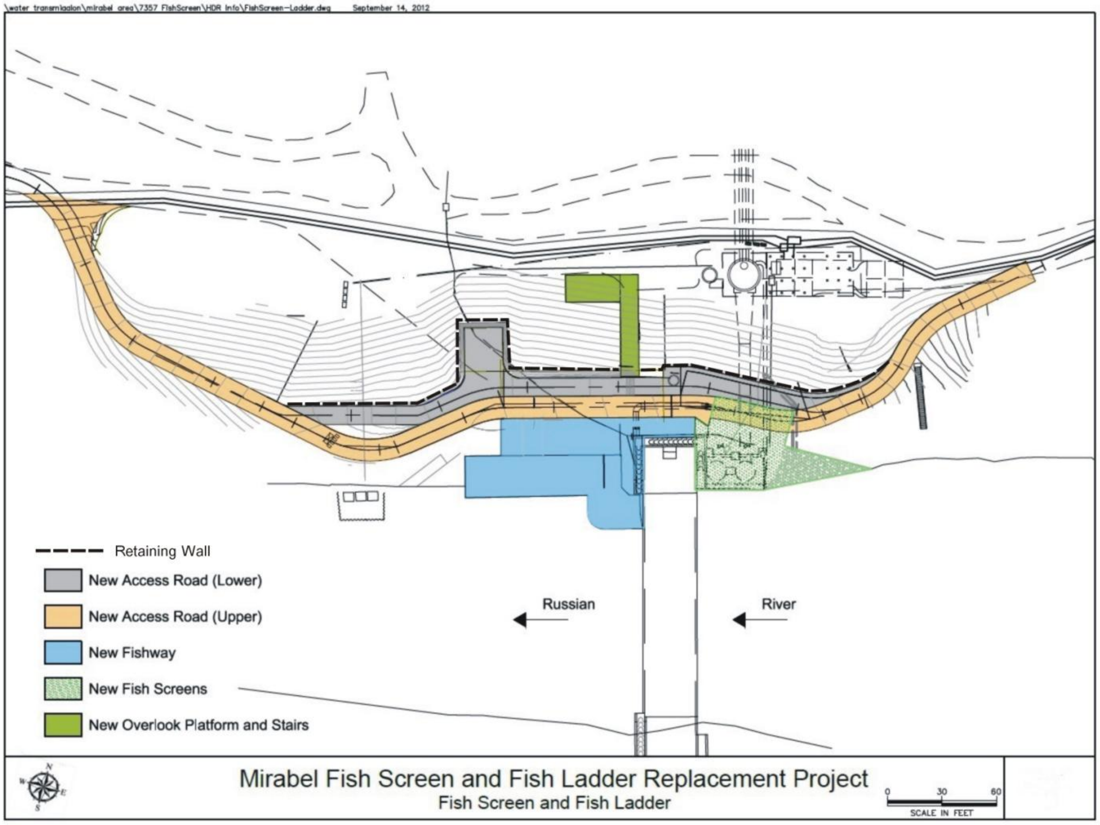

Figure 8.1.1. Planned modifications of Mirabel diversion facility and fish ladders.

Figure 8.1.2. Conceptual design of modified Mirabel diversion facility showing new fish screens upstream of the dam, a vertical slot fishway below the dam, and a new access road to the site.

area in the event of an earthquake. The seismic ground improvements would consist of penetrating the soil with auger holes and installing stone columns within the soil matrix, within the liquefaction zone. The auger holes would be approximately (approx.) 3 feet (ft.) in diameter and 40-80 ft. deep, at locations on the east side (river side) and the west (sedimentation pond side) of the access road in the project area. They would be spaced on a 6 -9 ft grid throughout the disturbance area for a total of approximately half an acre of disturbance area, all outside of the ordinary high water mark. The holes would then be filled with rock that is vibrated into the soil matrix, causing the soil to liquefy, and then densify, providing increased bank stabilization. The seismic stability work is scheduled to occur between January 2014 and May 2014.

In June of 2014, the main construction activities associated with the fish screen replacement is anticipated to begin.

Fish Screen

The proposed intake screen would consist of six 12-foot tall by 6-foot wide panels, with a total area of 432 square feet. The new fish screen would also incorporate a cleaning system to ensure that the screen material does not become clogged. Clogged screens result in higher flows through unclogged portions of the screen, which can lead to fish getting trapped against the screen. The cleaning mechanism is anticipated to be an electric motor-driven mechanical brush system that periodically moves back and forth to clean the intake screen structure.

Fish Ladder

A vertical slot type fish ladder was selected as the recommended design to provide passage for upstream migrating salmonids. Vertical slot fish ladders are commonly used for salmon and steelhead (among other fish species) throughout the world. A vertical slot fish ladder consists of a sloped, reinforced concrete rectangular channel separated by vertical baffles with 15-inch wide slots that extend down the entire depth of the baffle. The baffles are located at even increments to create a step-like arrangement of resting pools.

The design would be self-regulating and provide consistent velocities, flow depths, and water surface differentials at each slot throughout a range of operating conditions. It is anticipated that the ladder would be configured to accommodate a range of fish passage conditions while the Mirabel Dam is up and river flows ranging from 125 to 800 cubic feet per second. Fish passage while the Mirabel Dam is down would also be accommodated, but is not the primary focus of design. The fish ladder would extend approximately 100 feet further downstream than the existing fish ladder at the site.

Fisheries Monitoring Components

The Water Agency currently conducts a variety of fisheries monitoring activities at its Mirabel Dam facilities. The new fish ladder design would support these monitoring activities by providing a dedicated viewing window and video equipment room and a fish trapping and holding area built into the fish ladder. The monitoring information collected by Water Agency staff is critical in tracking population trends and movement of different species in the Russian River system.

Education Opportunities

The existing facility at Mirabel is visited every year by approximately 3,000 schoolchildren as part of the Water Agency's water education efforts. The existing facility allows schoolchildren to see a critical component of the Water Agency's water supply system, but the views of the top of the existing fish ladder do not offer much opportunity for observing and learning about the fisheries of the Russian River system. The proposed project would include a viewing area, separate from the video monitoring viewing window, which would allow visitors to see into the side of the fish ladder. The educational experience for schoolchildren would be improved by having the opportunity to actually see fish travelling up or down the fish ladder.

Additional Features

The project design would also include a variety of other components that would support the primary fish screen and fish ladder aspects of the project. These other components consist of items such as replacement of the buoy warning line upstream of the Mirabel Dam, modification of the existing access road to the project site, and the installation of a viewing platform to allow visitors a safe location to view the overall facility. The existing access road down to the Mirabel Dam is a steep one-way road. Vehicles going down to the Mirabel Dam area must be turned around or backed up the road down to the project site. The proposed project includes a modification of the access road so that the road will not be as steep and will include both an entrance and exit ramp from the Mirabel Dam site. Because the site is a major component of the Water Agency's water education program where several thousand schoolchildren are brought out to the site each year, the design for the new access road also includes a parking area at the Mirabel Dam that is compliant with Americans with Disabilities Act access standards. The viewing platform would be a deck area at the elevation of the existing upper levee road above the Mirabel Dam that would allow visitors to the site to view the facility. A stairway from the top of bank down to the Mirabel Dam would allow visitor access from the upper levee road area down to the Mirabel Dam.

8.2 Mirabel Fisheries Monitoring

2012 marked the 13th year that fishery studies have been conducted at the Wohler-Mirabel site. Although this report details the findings of the 2012 sampling season, data from previous years will be included to provide historical context. Fisheries studies at Mirabel Dam were developed in cooperation with the National Marine Fisheries Service and the California Department of Fish and Wildlife to assess the potential for the dam to adversely impact listed species through: 1) altering water temperature and water quality in the lower river, 2) impeding downstream migration of juveniles, 3) impeding upstream migration of adults, and 4) altering habitat to favor predatory fish. The results of the initial 5-year study are presented in Chase *et al.* 2005, and Manning *et al.* 2007. Since 2005, the studies have focused on providing a long-term record of adult Chinook salmon escapement and juvenile salmonid emigration, as well as collecting basic life history information on all species migrating past the Inflatable Dam.

Mirabel Downstream Migrant Trapping

The Water Agency has collected juvenile emigration data below the Inflatable Dam since 2000. Two rotary screw traps are generally fished below the dam from approximately April 1 through mid-June or July, depending on annual flow conditions. Data collected includes run timing, species composition, relative abundance, age, and size at emigration.

Methods

The rotary screw trap site is located approximately 40 m downstream of the Inflatable Dam. In 2012, two rotary screw traps (one 1.5-m diameter and one 2.5-m diameter) were operated. Trapping is initiated during the spring when streamflows decrease to levels suitable to safely and efficiently operate the traps. In 2012, the traps were deployed on April 25 at a flow of 1,120 cfs, and fished through the morning of July 3 at a flow of 112 cfs (flows recorded at the Hacienda Gauge).

Fish captured were netted out of the live well and placed in an insulated ice chest supplied with freshwater. Aerators were operated to maintain DO levels in the ice chest. Prior to data collection, fish were transferred to a 19-liter bucket containing water and Alka-seltzer, which was used as an anesthetic. Fish captured were identified to species and measured to the nearest mm (FL). After data collection, fish were placed in a bucket containing fresh river water. Dissolved oxygen levels in the recovery buckets were also augmented with aerators to maintain DO level near saturation. Once the fish regained equilibrium, they were released into the river downstream of the screw traps. In accordance with Water Agency's NMFS Section 10 Research Permit, once water temperatures exceeded 21.1˚C, salmonids were not anesthetized, but were netted from the live well, identified, enumerated, and immediately released below the traps.

In 2012, a mark-recapture study was initiated on April 25 (first day of trapping) and conducted through July 1 in an attempt to estimate the number of juvenile Chinook salmon emigrating past the dam. This study has been initiated each year since 2001[6] once the majority of juvenile Chinook salmon reach a minimum length of 60 mm FL (juveniles less than 60 mm FL are too small to safely mark). Chinook salmon captured in the traps were sub sampled, and up to 50 fish daily were marked with a small caudal clip. Marked fish were held in an ice chest equipped with aerators, and transported and released approximately 100 meters upstream of the dam. The proportion of marked to unmarked fish captured in the traps was then used to calculate a weekly estimate of the number of Chinook smolts emigrating past the dam (Bjorkstedt 2000). In addition to marking Chinook smolts, PIT tags were applied to young-of-the-year steelhead once they reached a length of ≥60 mm FL in length.

Results

In 2012, two rotary screw traps were operated for 67 days (Table 8.2.1). A total of 26 species including 6,216 individual fish were captured (excluding larval suckers and cyprinids). The catch included 14 species native to the Russian River. Three species, Chinook salmon, steelhead, and Pacific lamprey ammocoetes accounted for 72.6 percent of the total catch.

Chinook salmon

The relatively high flows in April (9,470 – 1,170 cfs between the 1st and the 24th) necessitated a late start to the trapping season in 2012. As a result, the first half of the run was missed. A total of 2,307 juvenile Chinook salmon were captured in 2012. Chinook smolts were captured from the first day of sampling through the last day (April 25 – July 3) (Table 8.2.2). Excluding 2009 and 2010, overall trapping efficiency has ranged from 6.2 to 11.4 percent. In 2012, 1,777 Chinook salmon smolts were marked and released upstream of the dam. Of these, 121 (6.8 percent) were recaptured. Based on the DARR estimator (Bjorkstedt 2000), the 2012 mark-recapture estimate was 57,004 (±20,560) juvenile Chinook salmon migrating past the trapping site during the mark-recapture study (Table 8.2.3). Chinook salmon emigration typically peaks in April and May, before slowly declining from June into July. The truncated sampling period in 2012 precludes assessing the run during the early portion of the season; however, 2012 appeared to be following a similar trend (Figure 8.2.1)

Average fork lengths for Chinook salmon ranged from 77.8 mm in late April to 98.9 mm by late June (Figure 8.2.2). Weekly average fork lengths in 2012 were similar to the 13 year mean.

[6] Excluding 2005 and 2006 when high streamflows curtailed downstream migrant trapping

Table 8.2.1. Summary of Mirabel Dam rotary screw operations from 2000 to 2012.

Year	Deployment date	End date	Dam inflated	Dates of non-operation	Number of days operated
2000	April 8	June 29	May 2	April 18, 19	80
2001	April 20	June 7	April 21	April 22; May 28, 29	47
2002	March 1	June 27	April 16	April 16	118
2003	March 1	July 3	May 23	March 15-19; April 13-21; April 24-May 11; May 23	92
2004	April 1	July 1	April 8	April 8	91
2005	April 15	June 30	May 26	May 19-23; May 27-31	67
2006	May 4	May 24	May 11	May 12-15	17
2007	March 21	June 28	March 28	March 30; May 30	98
2008	March 20	June 26	April 11	Apil 11-13; May 17-18; June 10, 16, 24	91
2009	April 1	July 17	July 8	April 15; May 5-7; July 2, 9, 14	101
2010	May 4	July 16	June 11	--	74
2011	April 15	July 19	May 9	May 2, 3, 10	93
2012	April 25	July 3	May 31	May 31; June 2, 18	67

Table 8.2.2. Weekly capture of Chinook salmon at the Wohler trapping site, 2000 – 2012.[1]

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
26-Feb			45	332									
5-Mar			74	841									
12-Mar			319	89									
19-Mar			181	169				257	114				
26-Mar			797	346				940	80	6			
2-Apr	41		908	377	82			730	224	257			
9-Apr	158		757	176	115	446		564	100	236		263	
16-Apr	154	122	2,279	17	672	848		1,011	866	190		815	
23-Apr	204	720	2,992	60	1,911	618		759	1,161	159		269	165
30-Apr	169	1,338	4,337	0	1,845	353		1,148	315	67	86	628	170
7-May	121	1,154	1,780	50	1,631	132	69	782	258	149	451	1,732	567
14-May	174	226	2,056	508	552	222	46	880	381	123	187	2,820	415
21-May	106	76	1,755	690	158	35	217	698	91	55	158	2,967	256
28-May	92	64	704	1,461	150	419	67	503	107	64	268	1,802	130
4-Jun	66	22	192	530	125	541		857	60	42	145	924	287
11-Jun	47		93	374	31	136		268	94	30	155	372	87

18-Jun	19		46	186	88	156		45	19	9	324	437	87
25-Jun	10		4	86	26	55		38	8	2	441	226	134
2-Jul				3						8	71	49	9
9-Jul										1	72	33	
16-Jul										1	10	12	
Total	**1,361**	**3,722**	**19,319**	**6,295**	**7,386**	**3,961**	**399**	**9,480**	**3,878**	**1,399**	**2,368**	**13,349**	**2,307**

[1]Please note that the dates when the traps were deployed and the length of time that the traps were operated differs between years (see Table 8.2.1).

Table 8.2.3. Estimated number of juvenile Chinook salmon that passed the Mirabel Dam site, based on mark-recapture trap efficiency testing, from 2001 to 2012.

Year[1]	Number of days studied	Number marked	Number recaptured	Overall efficiency	Seasonal estimate[2]	95% CI
2001	34	525	60	11.4	19,473	5,022
2002	76	2,778	253	9.1	225,135	37,028
2003	26	1,072	90	8.4	45,699	18,218
2004	40	1,631	120	7.4	91,352	17,652
2005	0	N/A	N/A	N/A	N/A	N/A
2006	0	N/A	N/A	N/A	N/A	N/A
2007	76	3,201	203	6.3	149,329	28,722
2008	42	1,321	88	6.7	43,774	16,768
2009	51	709	20	2.8	41,663	10,208
2010	69	1,881	76	4.0	109,540	47,463
2011	62	2,763	172	6.2	305,361	84,941
2012	67	1,761	121	6.9	57,004	20,560

[1]Includes fish captured outside of the mark-recapture study period.

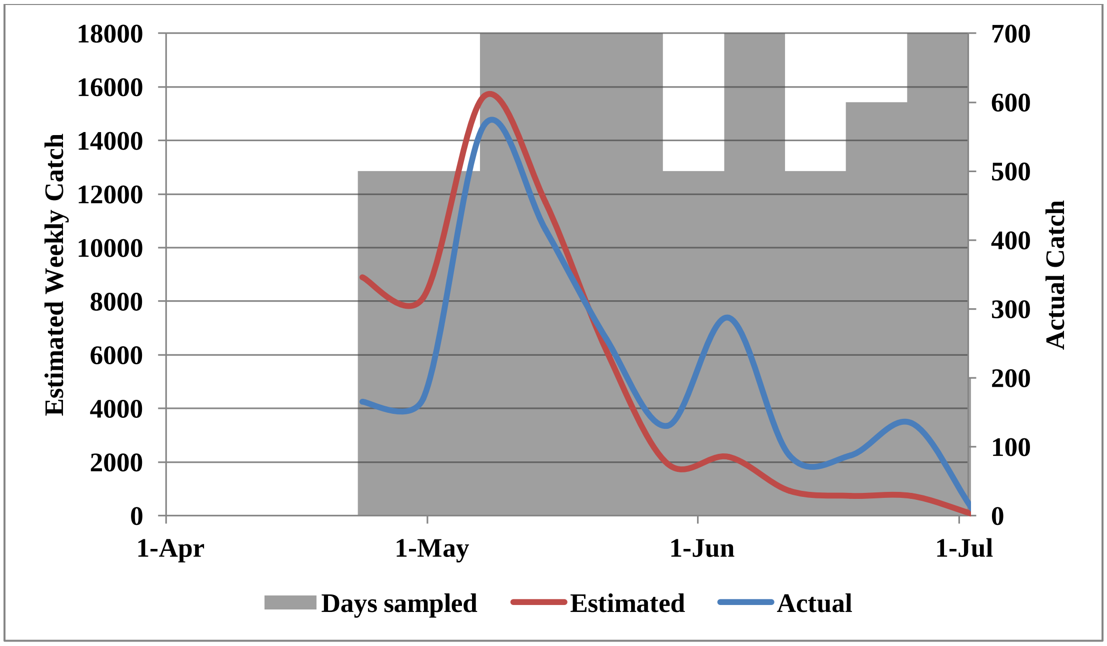

Figure 8.2.1. Weekly estimated and actual catches at the Mirabel Dam downstream migrant trap, 2012.

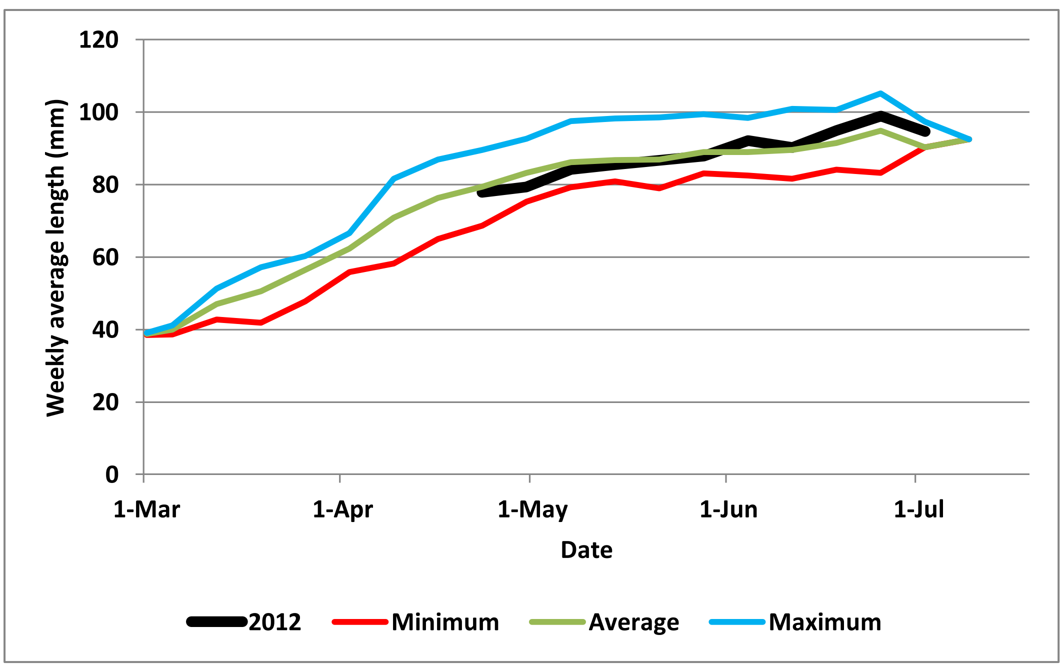

Figure 8.2.2. Weekly average fork lengths of Chinook salmon smolts measured at the Mirabel Dam trap site in 2012 (black line) compared to the minimum, average, and maximum lengths between 2000-2012.

Steelhead

For the season, 983 wild (natural origin) steelhead parr were captured, most of which were likely YOY based on length-frequency data (Table 8.2.4, Figure 8.2.3). In addition, 79 wild origin steelhead smolts were captured between April 26 and June 27 (Table 8.2.5). In 2012, 315 PIT tags were applied to steelhead captured at Mirabel (results of the PIT tag study are discussed in the synthesis chapter of this report.

Steelhead smolts ranged in length from 136 to 263 mm FL, averaging 178.6 mm FL overall (Figure 8.2.4). Since 2000, the average size of steelhead smolts has ranged from 161 to 185 mm FL (Table 8.2.6).

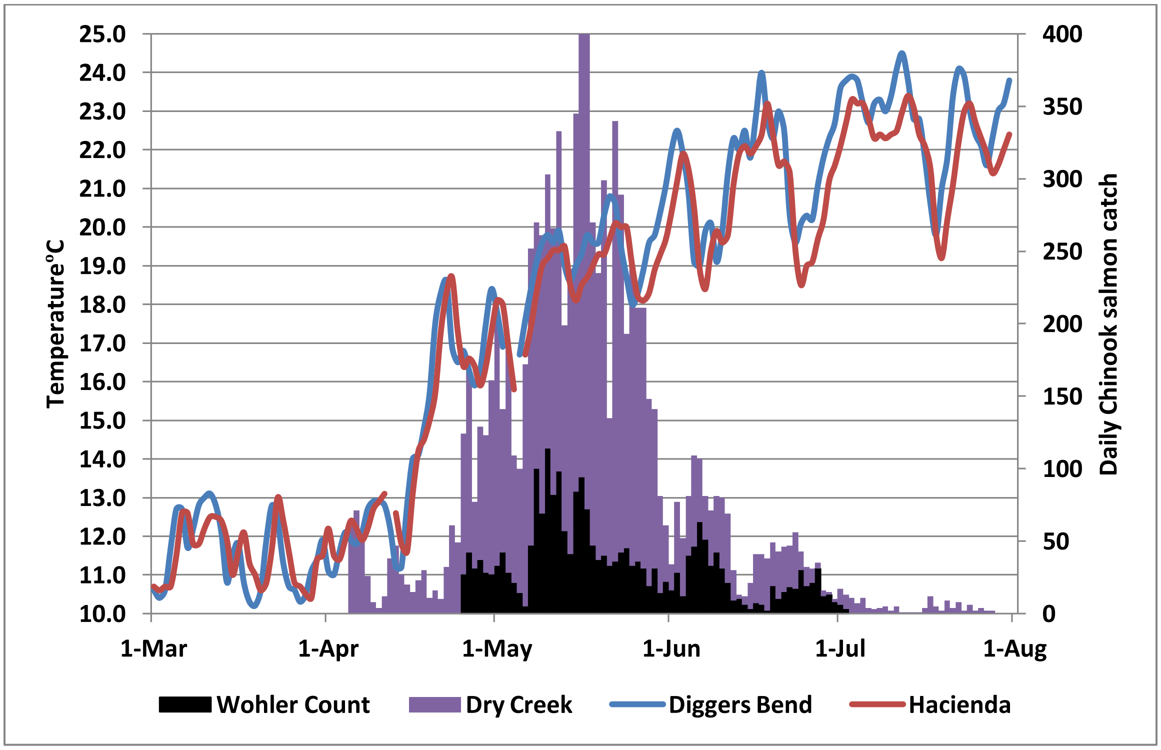

Figure 8.2.3. Daily catch of Chinook salmon at Dry Creek and Wohler and the average daily temperatures recorded at the Diggers Bend, Hacienda, and Dry Creek USGS stream gauges, 2012 (note: trapping efficiency at the Dry Creek trap is higher compared to that at Wohler).

Table 8.2.4. Weekly catch of steelhead young-of the year (age 0+) and parr (age 1+) at the Mirabel Dam trapping site, 2000 – 2012.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
26-Feb	--[1]	--	0	1	--	--	--	--	--	--	--	--	--
5-Mar	--	--	0	5	--	--	--	--	--	--	--	--	--
12-Mar	--	--	1	3	--	--	--	--	--	--	--	--	--
19-Mar	--	--	8	13	--	--	--	1	1	--	--	--	--
26-Mar	--	--	3	67	--	--	--	27	7	--	--	--	--
2-Apr	--	--	56	170	3	--	--	8	14	4	--	--	--
9-Apr	3	--	51	132	14	86	--	12	35	4	--	--	--
16-Apr	20	1	447	4	12	100	--	39	34	4	--	2	--
23-Apr	33	17	81	20	16	97	--	136	74	8	--	3	1
30-Apr	224	4	658	0	10	523	14	58	118	11	33	13	40
7-May	30	13	756	22	3	354	12	164	133	7	36	168	140
14-May	49	23	976	74	1	75	182	157	52	3	39	55	399
21-May	80	34	1315	246	1	25	26	185	101	8	81	62	114
28-May	74	32	806	223	2	110	--	173	59	6	60	58	67

4-Jun	102	26	467	55	2	136	--	684	76	2	26	119	91
11-Jun	40	--	164	29	1	40	--	176	50	8	41	11	53
18-Jun	58	--	60	28	10	29	--	5	26	4	22	25	35
25-Jun	50	--	1	2	7	9	--	22	10	4	25	6	36
2-Jul	--	--	--	1	--	--	--	--	--	1	8	5	7
9-Jul	--	--	--	--	--	--	--	--	--	0	2	1	--
16-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--
23-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--
Total	**763**	**150**	**5,850**	**1,095**	**82**	**1,584**	**234**	**1,847**	**790**	**74**	**373**	**528**	**983**

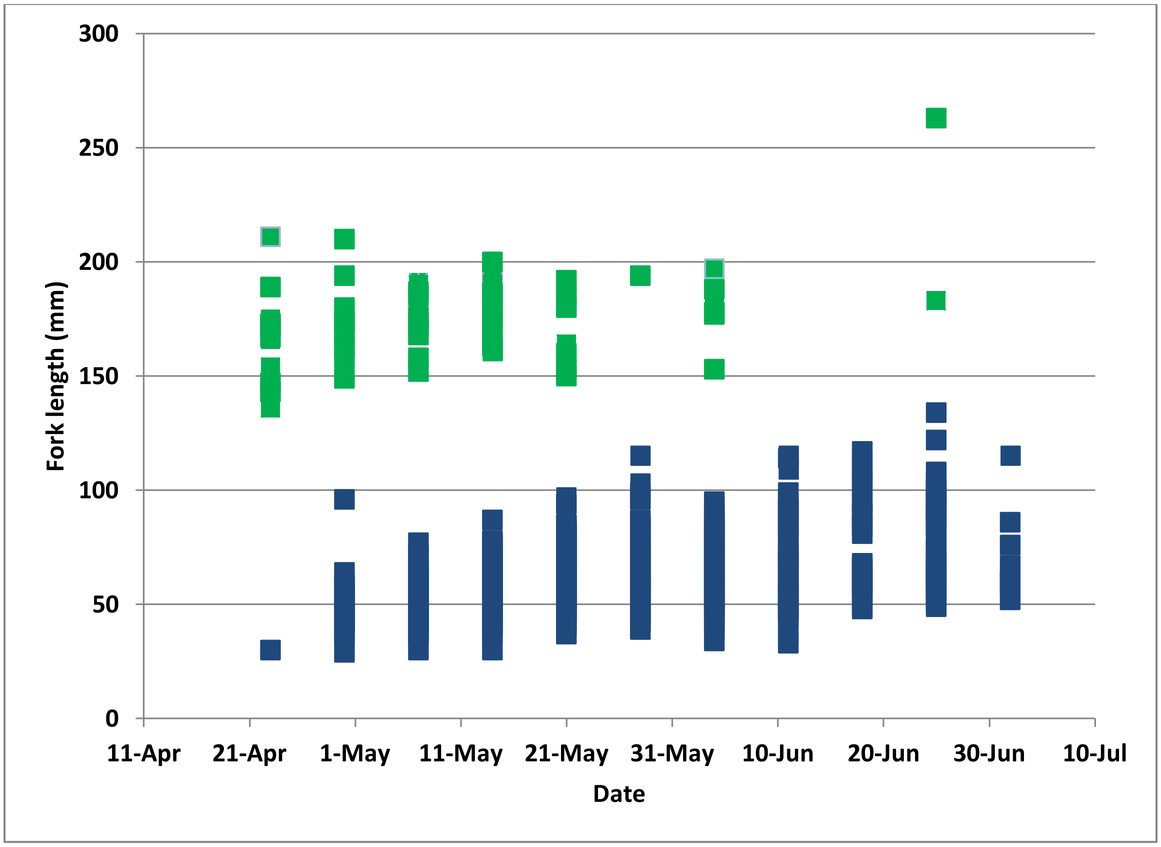

Figure 8.2.4. Length of steelhead captured in 2012, grouped by week of capture. Blue squares represent young-of-the-year (age 0+) and parr (age 1+), and green squares represent smolts (primarily age 2+).

Figure 8.2.5. Weekly catch of steelhead smolts at the Mirabel trapping site, 2000 – 2012.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
26-Feb	--[1]	--	1	4	--	--	--	--	--	--	--	--	--
5-Mar	--	--	1	3	--	--	--	--	--	--	--	--	--
12-Mar	--	--	38	5	--	--	--	--	--	--	--	--	--
19-Mar	--	--	15	3	--	--	--	24	0	--	--	--	--
26-Mar	--	--	24	39	--	--	--	99	1	--	--	--	--
2-Apr	--	--	31	39	3	--	--	24	3	12	--	--	--
9-Apr	19	--	33	18	14	0	--	25	0	5	--	1	--
16-Apr	24	7	30	--	11	18	--	43	4	5	--	16	--
23-Apr	24	16	23	--	14	9	--	61	8	2	--	6	11
30-Apr	21	16	23	--	10	7	9	14	12	1	4	6	11
7-May	8	9	7	--	3	3	10	17	4	1	8	27	15
14-May	14	4	9	26	1	1	5	11	0	2	14	54	18
21-May	9	0	9	16	1	3	6	3	1	2	9	17	9
28-May	6	0	3	6	1	0	--	2	0	0	4	13	2
4-Jun	1	1	0	2	2	3	--	1	0	0	1	9	8
11-Jun	4	--	1	1	1	2	--	0	0	0	4	2	3

18-Jun	2	--	0	0	2	1	--	0	0	2	--	--	0
25-Jun	2	--	0	0	0	1	--	0	0	0	--	--	2
2-Jul	--	--	--	--	--	--	--	--	--	1	--	--	0
9-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--
16-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--
23-Jul	--	--	--	--	--	--	--	--	--	0	--	--	--
Total	**134**	**53**	**248**	**162**	**63**	**48**	**30**	**324**	**33**	**33**	**44**	**151**	**79**

[1]Traps were not operated during this week.

Coho salmon

Coho smolts were captured between April 25 (first day of sampling) and July 3 (June 3 for wild coho smolts). For the season, 26 wild smolts, 270 hatchery smolts, and 45 wild parr were captured (Table 8.2.6). Wild coho smolts ranged in length from 98 to 148 mm FL, averaging 119 mm. Hatchery coho smolts ranged from 91 to 162 mm FL, averaging 116 mm FL (Figure 8.2.5).

Conclusions and Recommendations

This project is an essential component of the overall Russian River fisheries monitoring program and provides valuable information that informs the management of all three listed species. Data collected at the Mirabel trapping site provides long term trends in smolt emigration past the Wohler-Mirabel facility, as well as insights into their life history strategies.

Based on 13 years of sampling, juvenile Chinook salmon are present in the river by at least late-February, with peak captures at Mirabel typically occurring between mid-March and mid-May. However, significant numbers of Chinook smolts have been captured through June and into July in some years. The timing of salmonid smolt emigration through the lower river is significant because water temperatures in the mainstem Russian during the late spring can reach levels stressful to smolts. Water temperatures recorded at the Diggers Bend and at the Hacienda gauges generally exceed 20°C by mid-to-late-May. Increasing water temperatures in the upper river likely stimulate mainstem rearing fish to emigrate (Figure 8.3.5). However, in Dry Creek water temperatures are controlled by releases from the dam, and remain cold even during the heat of summer. This modified temperature regime likely dampens natural thermal cues motivating juvenile salmonids to emigrate. Average daily water temperature at Diggers Bend exceeded 20.0°C on May 20, and increased to 22.3°C on June 12. The rise in water temperature at Diggers Bend would likely stimulate salmonids rearing in the upper river to begin migrating downstream. Conversely, in Dry Creek the average water temperature was <14.0°C in late May. The significance of this is that water temperature in the lower Russian River may increase to stressful levels by mid-June (On June 11th, 2012, the mean daily water temperature at Hacienda was 21.1°C). Juvenile salmonids leaving Dry Creek during the end of the migration period are exposed to potentially stressful conditions.

Juvenile steelhead (mainly young-of-the-year) captures at the Wohler-Mirabel traps peak in May, with low numbers being caught through June. Juvenile steelhead abundance likely reflects the timing of emergence as well as flow and water temperature conditions at the trap. Rearing in the lower river is likely limited by water temperatures during the late spring/early summer period. At Mirabel, water temperatures typically exceed 21°C by mid-June. Although we have observed low numbers of steelhead rearing above and below the dam

Table 8.2.5. Weekly catch of coho salmon smolts at the Mirabel Dam trapping site, 2006 – 2012. Most fish were marked from the Russian River Coho Salmon Hatchery Broodstock Program.

	2006	2007	2008	2009	2010	2011	2012
26-Feb	--	--	--	--	--	--	--
5-Mar	--	--	--	--	--	--	--
12-Mar	--	--	--	--	--	--	--
19-Mar	--	3	1	--	--	--	--
26-Mar	--	1	6	4	--	--	--
2-Apr	--	0	6	23	--	--	--
9-Apr	--	2	2	35	--	16	--
16-Apr	--	9	10	38	--	362	--
23-Apr	--	8	16	33	--	111	78
30-Apr	1	15	17	3	38	45	52
7-May	1	38	23	26	53	51	83
14-May	1	24	9	23	30	138	48
21-May	0	7	1	9	15	83	15
28-May	--	1	0	7	21	31	9
4-Jun	--	0	0	1	19	32	7
11-Jun	--	0	0	4	0	11	3
18-Jun	--	0	0	0	3	2	0
25-Jun	--	0	0	0	1	0	0
2-Jul	--	--	--	0	0	0	1
9-Jul	--	--	--	0	1	1	--
16-Jul	--	--	--	0	--	--	--
Total	**3**	**108**	**91**	**206**	**181**	**891**	**296**

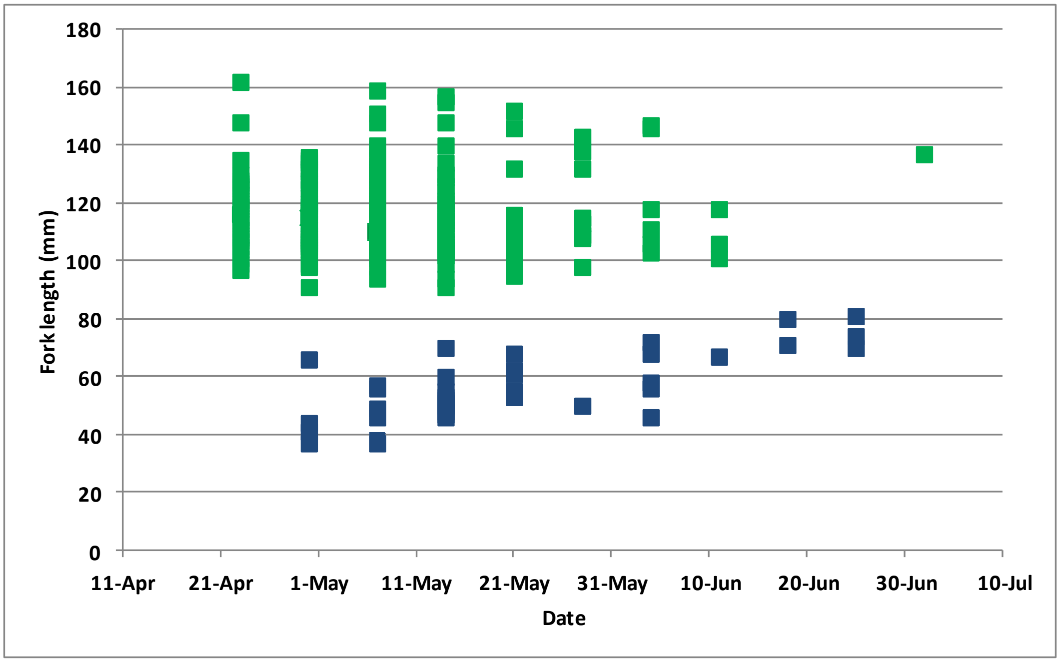

Figure 8.2.6. Lengths of coho salmon captured in 2012 grouped by week of capture. Blue squares represent young-of-the-year (age 0+), and green squares represent smolts (primarily age 1+).

during the summer, conditions are stressful (mid-summer temperatures approach or exceed 25.0°C), and few steelhead have been observed rearing in this reach of the river.

Although data are limited, coho appear to migrate past the Inflatable Dam primarily in April and May, with a few fish being detected through June. The time of year and the numbers of hatchery smolts captured at the trap may be influenced by the stocking practices of the Coho Broodstock Program, and may not reflect the true abundance or run timing of these fish. Numbers of wild coho smolts have ranged from 1 in 2010, to 26 in 2012.

8.3 Mirabel Fish Ladder Video Monitoring

The Inflatable Dam is approximately 4.0-m high, 45-m wide, and when fully inflated forms a barrier to upstream migrating fish. Upstream passage around the dam is provided by two Denil-type fish ladders. The dam is typically inflated from early spring through late-fall, depending on water demand and streamflow. In most years, the dam is inflated during the majority of the Chinook salmon run and the beginning of the coho salmon run. During years with low rainfall in the fall and early winter, the dam may also be inflated during the majority of the coho salmon run, as well as the beginning of the steelhead migration period.

The video counting system was originally designed to assess the effectiveness of the fish ladders at the Wohler Dam (2000-2004). Since the completion of this initial study, the system has been operated to document Chinook salmon escapement to the upper river. Since the vast majority of Chinook salmon spawning habitat lies above the dam, the counting station provides a good estimate of the overall run in the Russian River. However, during periods of high turbidity (generally associated with high streamflows), the cameras are ineffective and some portion of the run is missed in most years. In 2011, a DIDSON (dual-frequency identification sonar) was installed at the upstream ends of both fish ladders. These units effectively detect and record images of fish passing upstream of the fish ladders during periods of high turbidity. However, with a few exceptions, the images of fish passing through the fish ladder cannot be identified to species. In addition, the DIDSON cameras, like the digital cameras, can only operate when the dam is inflated. Therefore, all counts of fish should be regarded as a minimum escapement.

Methods

The passage of adult salmonids through the fish ladders was assessed using digital underwater video cameras from September 1 until November 21, 2012, when high stream flows resulted in the deflation of the dam for the season. Each year, metal housings (camera boxes) are installed at the upstream end of each fish ladder. Underwater cameras and lighting systems are located in the boxes, and are operated 24 hours a day, 7 days a week. Video data are stored on a hard drive located in a nearby building. Each morning, data stored on the hard drive are downloaded directly to the office where it is reviewed. Once viewed, the video footage is copied to 8 GB DVDs for archival purposes.

Fish were counted as moving upstream once they exited the upstream end of the camera box. For each adult salmonid observed, the reviewer recorded the species (when possible), date, and time of passage out of the ladder. During periods of low visibility it was not always possible to identify fish to species, although identification to family (e.g., Salmonidae) was often possible, and such fish were lumped into a general category called simply “Salmonid.” Fish that were identified as a salmonid, but could not be identified to species were partitioned into Chinook, coho or steelhead in an attempt to better estimate the number of each of these species observed in the fish ladders. Salmonids were partitioned by taking the proportion of each species identified in the ladder each day, and multiplying the number of salmonids by these proportions. On days when no salmonids could be identified to species, an average ratio from adjacent days was used to categorize the unidentified salmonids.

In most years, high turbidity events associated with rainstorms reduces visibility to the point where the cameras become inoperable. In 2012, the Water Agency deployed a DIDSON (on loan from the Department of Fish and Wildlife) at the exit to each fish ladder in order to count fish passing during periods of high turbidity. The DIDSON can record images of fish passing out of the fish ladders during periods of high turbidity. The DIDSON operated continuously as a backup for the video cameras

Results

In 2012, the cameras were in operations continuously from September 1 to November 21 (Table 8.3.1). During the majority of the season, the image quality of the videos was sufficient to identify and count fish passing through the fish ladder. Species observed in the last 13 years include, but are not limited to Chinook and coho salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, common carp, and channel catfish.

Salmonids

In 2012, 410 ”Salmonids” (i.e., the fish had the generalized body shape of either a salmon or steelhead, but due to either poor image quality or visibility, could not be identified to species) were tallied at the Mirabel Dam. This total includes 50 fish observed with the DIDSON units during a period of high turbidity just prior to the deflation of the dam. Based on the proration process, the 410 salmonids were partitioned as 349 Chinook salmon, 23 coho salmon, and 38 steelhead.

Chinook

The total count for Chinook salmon (6,696 adults including “Salmonids”) surpassed the previous record by 593. Chinook were still migrating past the dam when it was deflated due to a large storm event, thus the total under represents the true number of returning adults in 2012. Previous to 2012, the number of adult Chinook salmon counted each year has ranged from 1,138 to 6,103 (average 3,272) (Table 8.3.2).

We detected seven Chinook strays during video monitoring. These fish were clearly identifiable as Chinook salmon and each possessed an obvious adipose

Table 8.3.1. Deployment and removal dates for the Mirabel underwater video system, 2000 – 2012.

Year	Date Deployed	Date Removed
2000	May 12	January 10 (2001)
2001	August 7	November 13
2002	August 12	December 11
2003	September 3	December 2
2004	August 1	December 8
2005	August 1	December 1
2006	August 14	November 26
2007	April 1	June 27
2007	August 15	December 15
2008	August 15	December 22
2009	August 15	December 16
2010	September 1	December 5
2011	September 1	January 17 (2012)
2012	September 1	November 21,

Table 8.3.2. Weekly count of adult Chinook salmon at the Mirabel Dam fish ladders, 2000 – 2012. Dashes indicate that no sampling occurred during that week.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1-Aug	0	0	0	--	0	0	--	--	--	--	--	--	--
8-Aug	0	0	0	--	0	0	--	--	--	--	--	--	--
15-Aug	0	0	1	--	0	0	0	0	0	0	--	--	--
22-Aug	1	0	8	--	0	1	0	0	0	0	--	--	--
29-Aug	0	3	7	2	1	2	0	0	1	0	0	0	0
5-Sep	9	1	18	7	1	5	0	0	0	0	0	0	1
12-Sep	38	7	19	20	3	11	2	0	1	0	0	0	2
19-Sep	23	12	65	23	8	13	3	0	14	0	3	1	0
26-Sep	50	17	1,223	181	16	20	7	1	65	0	1	157	70
3-Oct	31	240	113	146	42	34	120	7	122	21	669	534	51
10-Oct	115	51	628	515	51	114	255	38	109	394	896	390	551
17-Oct	81	10	272	232	585	403	531	28	11	362	154	1070	1886
24-Oct	466	300	153	532	2284	332	83	87	21	305	286[1]	273	996
31-Oct	63	661	505	2969	183	632	1169	250	243	75	95[2]	223	1654
7-Nov	24	81	2,337	1289	1164	735	696	115	427	217	174	90	619
14-Nov	182	--	20	47	217	172	472	475	13	229	43	120	851

21 Nov	200	--	37	95	57	91	53	60	24	63	113	266	16[3]
28 Nov	111	--	14	45	59	40	18	105	15	84	76	6	--
5-Dec	19	--	54	--	15	0	--	770	21	20	5	1	--
12-Dec	14	--	--	--	--	--	--	22	8	31	--	2	--
19-Dec	17	--	--	--	--	--	--	0	13	0	--	10	--
26-Dec	1	--	--	--	--	--	--	--	--	0	--	15	--
2-Jan	0	--	--	--	--	--	--	--	--	--	--	2	--
9-Jan	--	--	--	--	--	--	--	--	--	--	--	10	--
16-Jan	--	--	--	--	--	--	--	--	--	--	--	1	--
Total	**1,445**	**1,383**	**5,474**	**6,103**	**4,788**	**2,572**	**3,410**	**1,963**	**1,125**	**1,801**	**2,516**	**3,172**	**6,696**

[1]Dam was deflated for 3 days of this week

[2]Dam was deflated for 2 days of this week

[3]Only one day was sampled during this week

fin clip. It is likely that these fish were strays from a Central Valley (Sacramento River) hatchery.

The date that the first Chinook salmon was observed during video monitoring has ranged from August 20 to October 7 during the 13 years of video monitoring. In 2012, the first Chinook salmon was observed on September 7. However, only two adult Chinook salmon were observed prior to September 27. Similar to previous years, the Chinook salmon run peaked between mid-October and mid-November (Table 8.3.2, Figure 8.3.1).

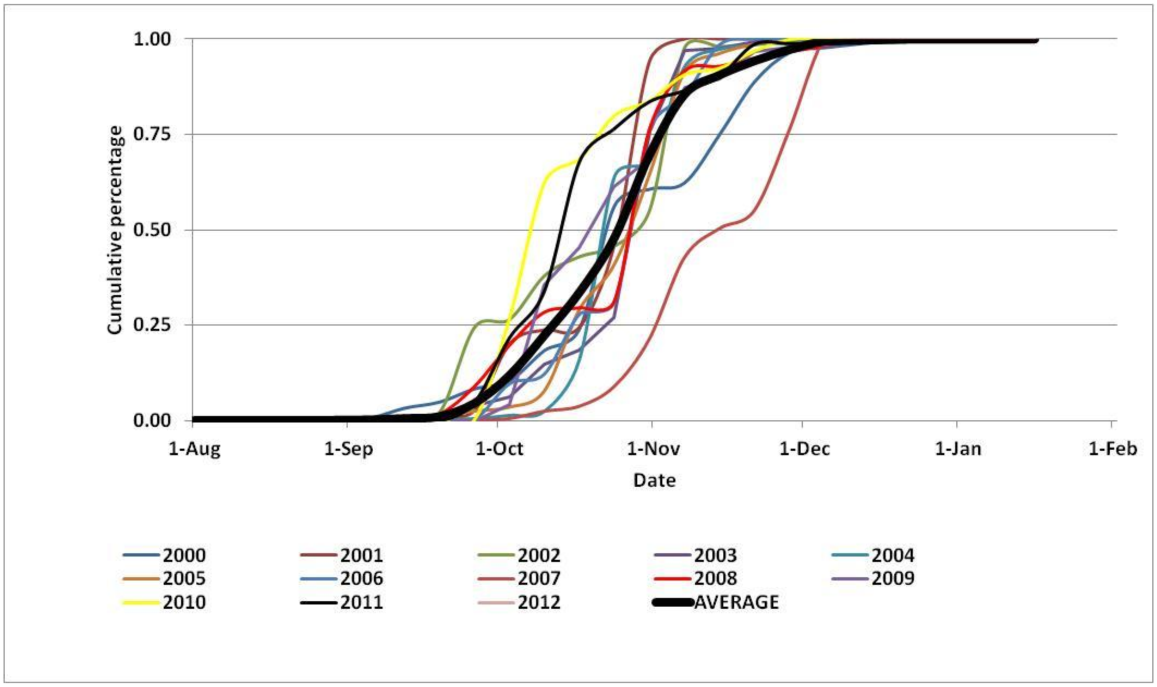

Figure 8.3.1. Cumulative percentage of the total number of adult Chinook salmon counted at the Mirabel Dam fish ladders each year from 2000 to 2012.

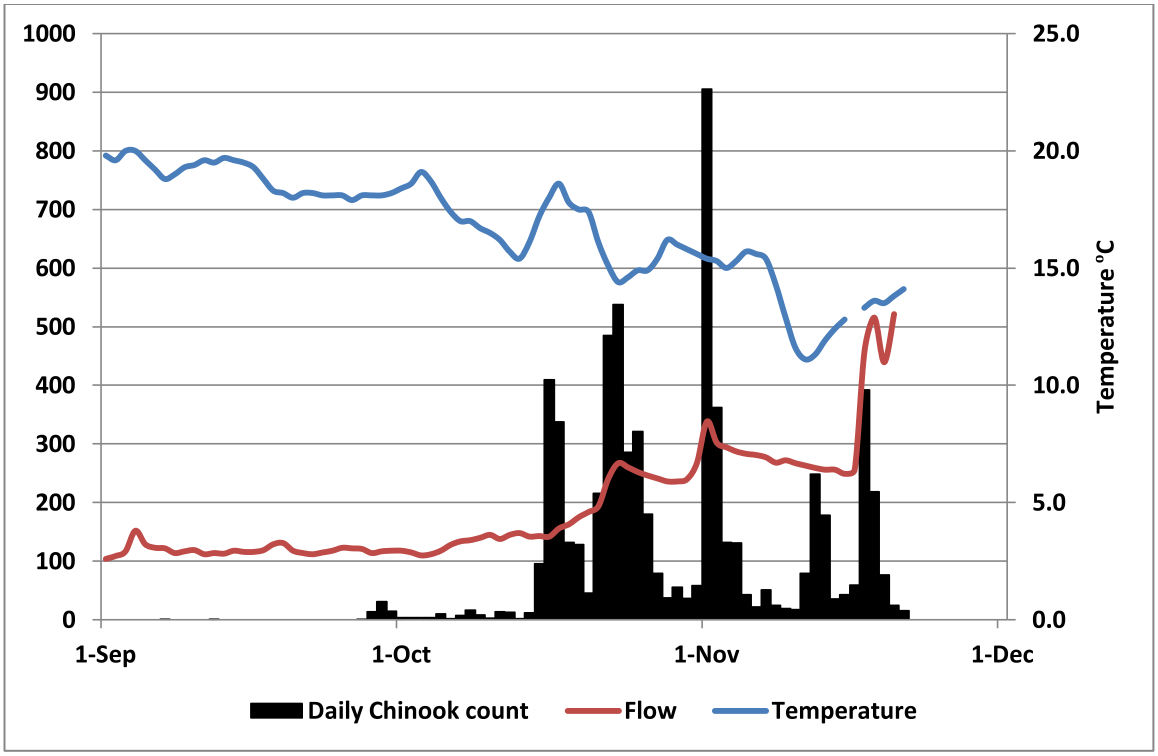

Figure 8.3. 2 Figure 8.3.6. **Daily Chinook salmon counts at Mirabel Dam, mean daily streamflow and mean daily water temperture recorded at the Hacienda gauge, September 1 through November 21, 2012.**

The Chinook salmon spawning migration is at least partially controlled by streamflow, water temperature, and dissolved oxygen levels. We assessed Chinook migration and streamflow by comparing fish counts at the dam with the previous 7-day running average recoded at Hacienda gauge. The lowest 7-day running average when Chinook were observed passing the dam was 118 cfs (Figure 8.3.2). The first significant pulse of Chinook salmon (411 on October 16) passed the dam at a flow (7-day running average) of 143 cfs (Hacienda Gauge). Streamflow did not appear to affect migration in 2012.

Water temperatures in the Russian River are suboptimal for Chinook salmon during the early stages of the run. In 2012, the mean daily temperature (MDT) was 18.8°C when the first Chinook salmon was observed at the counting station, and averaged 18.4°C during the first week of the run (September 27 – October 5) (Figure 8.3.2). During this time period, a total of 83 adult Chinook salmon were counted, and a total of 738 (11%) Chinook migrated past the dam when the mean daily temperature ranged between 18.0 and 18.6°C. Water temperatures typically decline in mid-late October, and the MDT was <16.5ºC when the majority (81%) of the Chinook salmon were detected at the Mirabel Dam. Dissolved oxygen levels were adequate for migration throughout the fall/winter migration period (≥8.9 ppm)

Coho

In 2012, 78 coho salmon were identified on the video system. These images were reviewed by multiple fisheries biologist from the Water Agency, NMFS, and University of California Cooperative Extension (UCCE). In addition, 23 of the 410 "Salmonids" were estimated to be coho salmon. Most of the coho salmon that were positively identified on the video system (64 of 78) were adipose fin clipped indicating that they were returns from the Russian River coho salmon broodstock program. Coho were observed migrating past the counting station from September 30 through November 20 (visibility decreased to the point where species identification was not possible late on the 20th, and dam deflation began on the 21st). The majority (87%) of the coho counted at the Inflatable Dam were observed after November 14th. Since the dam was deflated a week later, the majority of the coho salmon migration period was not captured by the video system.

Steelhead

In 2012, 119 adult steelhead were counted at Mirabel Dam (Table 8.3.3). In addition, 38 of the 410 "Salmonids" were estimated to be steelhead. Steelhead were categorized by being of wild, hatchery, or undetermined origin. Of the 119 steelhead that could be categorized by origin, 60 were identified as hatchery fish and 59 were identified as wild. Since 2000, few adult steelhead were observed prior to mid-November.

Table 8.3.3. Fall steelhead counts at the Mirabel Dam fish counting station in the fall of 2000-2012.

Date	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
8/1	0	0	0	0	0	0	0	0	--	--	--	--	--
8/8	0	0	0	0	0	0	0	0	--	--	--	--	--
8/15	0	0	0	0	0	0	0	0	0	0	--	--	--
8/22	0	0	0	0	0	0	0	0	0	0	--	--	--
8/29	0	0	0	0	0	0	0	0	0	0	0	0	0
9/5	0	0	0	0	0	0	0	0	0	1	0	0	0
9/12	0	0	0	0	0	1	0	0	0	0	0	0	1
9/19	0	0	0	0	0	0	0	0	0	0	0	0	2
9/26	0	0	0	0	0	0	0	0	0	0	0	1	2
10/3	1	0	2	0	0	1	0	0	2	0	0	9	5
10/10	0	0	0	1	0	2	0	1	1	9	8	10	20
10/17	0	0	3	0	1	3	0	0	0	19	8	8	1
10/24	2	0	1	2	6	3	1	0	1	1	0	5	6
10/31	2	0	3	0	0	2	0	0	9	2	5	8	7

11/7	1	0	18	4	3	12	6	0	5	8	2	11	3
11/14	7	--	10	18	14	9	25	4	15	2	22	8	87
11/21	11	--	1	17	34	21	--	15	4	12	36	110	22
11/28	56	--	9	36	97	14	--	194	35	18	72	36	--
12/5	43	--	55	--	52	--	--	46	18	33	10	23	--
12/12	178	--	--	--	--	--	--	--	112	51	--	60	--
12/19	87	--	--	--	--	--	--	--	55	--	--	78	--
12/26	24	--	--	--	--	--	--	--	--	--	--	105	--
1/2	45	--	--	--	--	--	--	--	--	--	--	66	--
1/9	56	--	--	--	--	--	--	--	--	--	--	80	--
TOTAL	513	**0**	**102**	**78**	**207**	**68**	**32**	**260**	**256**	**156**	**163**	**635**	**157**

[1]Wild, hatchery, and unknown origin combined.

Conclusions and Recommendations

The 2012 count of 6,696 Chinook salmon ranks as the highest total of the 13 years monitored at Mirabel Dam. Because counts at Mirabel are only possible when the dam is inflated and dam inflation is dependent on river flow, the length of time the video system is operated varies each year. Until the installation of the DIDSON system in 2012, turbidity sometimes limited our ability to count fish for days or weeks at a time. Therefore, Chinook counts at Mirabel represent minimum escapement to the Russian River and provide an index of total abundance. The Chinook salmon spawning run (typically) begins in mid-September, peaks between mid-October and mid-November, and tails off rapidly by late-December (Figure 8.3.5). The first Chinook salmon was observed at Mirabel on September 7, and the first significant pulse of fish (411) occurred on October 16.

Although Chinook salmon have been observed migrating past the Mirabel Dam at temperatures ranging to 22.6°C, in most years approximately 90 percent of the adult Chinook salmon have been observed at the fish counting station after the mean daily temperature (MDT) declines below 17.1°C (Table 8.3.4). Annually, 73 to 97 percent of the fish counted at the Mirabel Dam pass after the MDT declines below 15.5°C. The 15.5°C threshold is significant because exposure of migrating adults to temperatures above this point can result in decreased survival of developing embryos (Hinze 1959, cited by DW Kelly and Associates and 1992).

2012 marks the fourth year that coho salmon have been observed migrating upstream during the fall spawning run. Although the numbers counted have been low, the system does not detect fish that return to lower Russian River tributaries and is inoperable during a significant portion of the migration period during some years. However, the continued observations of both wild and hatchery reared coho salmon to the system, coupled with the observations of wild coho smolts successfully emigrating during the spring downstream migrant trapping season, provides evidence that the RRCSCBP is having a beneficial impact on the coho salmon population in the Russian River.

The majority of the adult steelhead run in the Russian River occurs after Mirabel Dam is deflated and fall video counts are not representative of run size and cannot be used to estimate steelhead abundance or to compare steelhead runs between years.

We recommend that the video system continue to be augmented with the DIDSON technology. The loss of video images due to episodic turbidity events is an ongoing issue with video technology. The inclusion of the DIDSON units will significantly reduce the loss of data and increase the total counts of fish migrating past the dam. Although it may not be possible to accurately identify species from the DIDSON images it should be possible to estimate the numbers of each species migrating past the dam by partition the DIDSON images by the percentage of each species identified on video.

Table 8.3.4. Date that the mean daily water temperature declined below 17.1 and 15.5°C and the percentage of the run that occurred after this date, 2000-2011.

Year	Date temp ≤ 17.1°C	Percentage of Chinook salmon counted on days when temp ≤17.1°C	Date temp ≤ 15.5°C	Percentage of Chinook salmon counted on days when temp ≤15.5°C
2000	Oct 11	86.5	Oct 22	76.4
2001	Oct 7	75.4	Oct 21	72.6
2002	Oct 9	97.7	Oct 16	59.4
2003	Oct 16	83.2	Oct 30	75.3
2004	Oct 10	98.4	Oct 13	96.7
2005	Oct 9	96.2	Oct 27	91.8
2006	Oct 11	99.6	Oct 18[1]	82.2[1]
2007	No data[2]	No data	No data	No data
2008	Oct 4	87.3	Oct 10	79.7
2009	Sept 30	93.9	Oct 28	62.2
2010	Oct 14	91.3	Oct 17	62.3
2011	Oct 24	52.0	Oct 27	28.9
2012	Oct 7	93.7	Oct 14	92.8

[1]Temperature data collection ended on October 18, 2006 when the MDT = 15.8°C. For this analysis it was assumed that the temperature would have declined below 15.5°C on October 19.

[2]Temperature probed failed, no temperature data collected in 2007.

9: Chinook Salmon Spawning Ground Surveys

Although not an explicit requirement of the Biological Opinion, the Water Agency has continued to perform spawning ground surveys for Chinook salmon in the mainstem Russian River and Dry Creek. This effort compliments the required video monitoring of adult fish migration and has been stipulated in temporary D1610 flow change orders issued by the State Water Resources Control Board to satisfy the Biological Opinion (see Pursue Changes to D1610 flow chapter of this report). The Water Agency began conducting Chinook salmon spawning surveys in fall 2002 to address concerns that reduced water supply releases from Coyote Valley Dam (Lake Mendocino) may impact migrating and spawning Chinook salmon (Cook 2003). Spawner surveys in Dry Creek began in 2003.

This report summarizes 2012 field studies on Chinook salmon spawning activity. Surveys were curtailed due to poor water visibility for detecting redds in the upper reaches of the Russian River. Hence, spawner surveys were only conducted in Dry Creek and in the Russian River mainstem from Cloverdale to below Healdsburg. Background information on the natural history of Chinook salmon in the Russian River is presented in the 2011 Russian River Biological Opinion annual report (SCWA 2011). The primary objectives of the spawning ground surveys are to (1) characterize the distribution and relative abundance of Chinook salmon spawning sites, and (2) compare annual results with findings from previous study years.

Methods

Chinook salmon redd (spawning bed) surveys were conducted in the Russian River from fall 2002 to 2012. Typically, the upper Russian River basin and Dry Creek are surveyed (Figure 9.1). The study area includes approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm), located south of Healdsburg, upstream to the confluences of the East and West Forks of the Russian River (154 rkm) near Ukiah. River kilometer (rkm) is the meandering stream distance from the Pacific Ocean upstream along the Russian River mainstem and for Dry Creek the distance from the confluence with the Russian River upstream. In 2003, the study area was expanded to include 22 rkm of Dry Creek below Warm Springs Dam at Lake Sonoma to the Russian River confluence. In 2012 Chinook salmon spawner surveys were not completed in the Canyon Reach (Hopland to Cloverdale) due to high turbidity levels that limited visual observations of redds. Also, water visibility was poor in Ukiah Reach that presumably impaired the detection of redds. Hence, the observations in this reach are presumed underestimates.

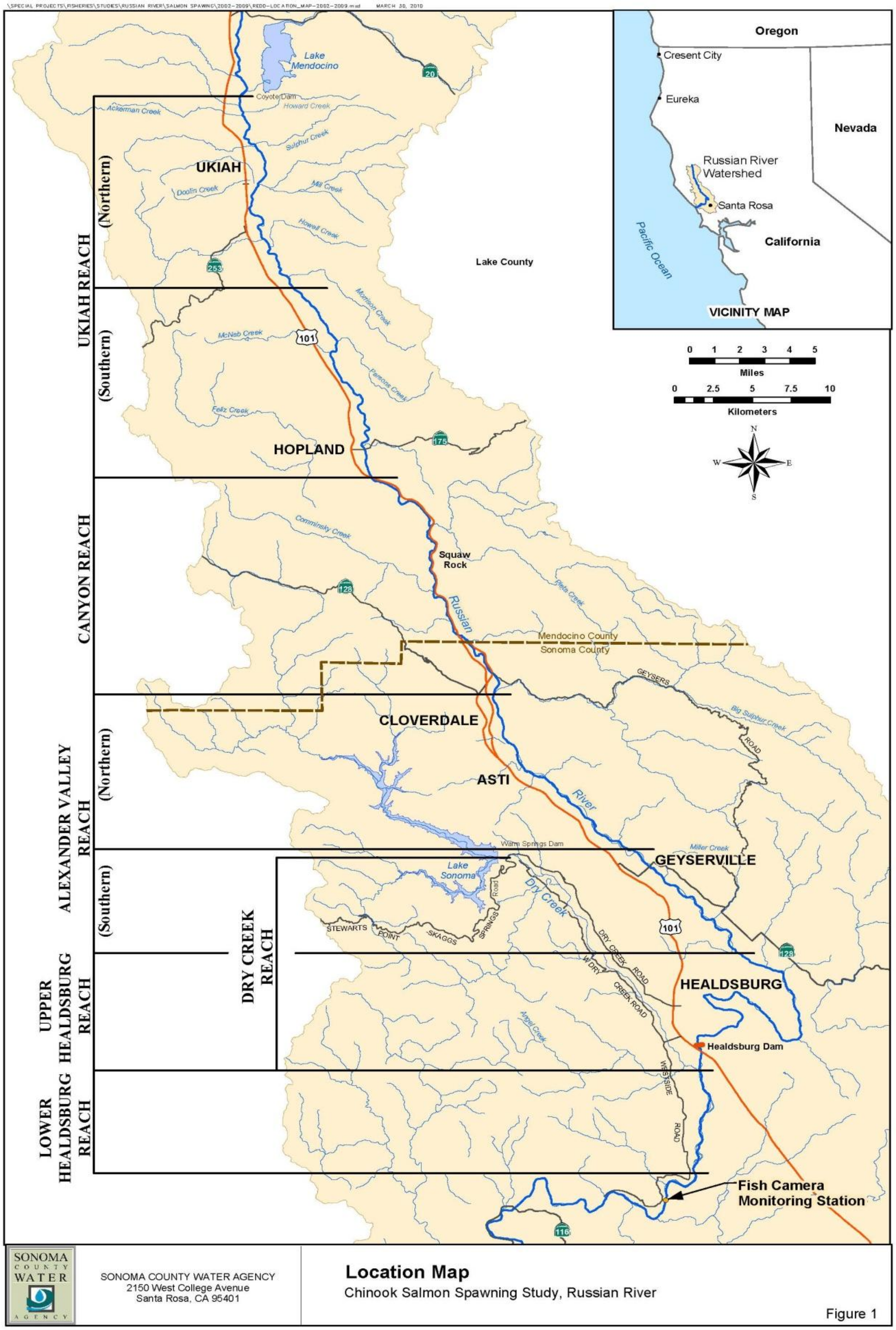

Figure 9.1. **Chinook salmon spawning survey reaches. The Canyon Reach was not surveyed in 2012.**

The Chinook salmon spawning ground study consisted of a single-pass survey during the estimated peak of Chinook salmon fall spawning. The Dry Creek and the Russian River study area were surveyed on November 14, 15, 26, and 27, 2012. A crew of two biologists in kayaks visually searched for redds along the streambed. Riffles with several redds were inspected on foot. The locations of redds were recorded using a global positioning system (GPS). Also, to better understand the ability to judge the peak of salmon spawning weekly single-pass surveys were completed along Dry Creek from October 30, and November 6, 13, 27, 2012. These weekly visits ended when runoff from heavy rainfall increased turbidity, which obscured the detection of redds.

Results

Most of the Chinook salmon spawning typically occurs in the upper Russian River mainstem and Dry Creek (Table 9.1). In 2012, the four mainstem reaches and Dry Creek Reach showed a similar pattern of relative abundance of redds as in previous study years with a general increase in redd numbers in an upstream direction. The exception was Ukiah Reach where there were proportionately fewer redds detected, which is likely from low detections from poor visibility. During 2012, Alexander Valley Reach had a total of 185 redds and the highest frequency of redds in the mainstem at 7.1 redds/rkm. In comparison, there were more redds recorded in Dry Creek Reach than Alexander Valley Reach, even though the latter has a longer stream length. During peak spawning activity, there were a maximum of 274 redds recorded from Dry Creek at a frequency of 12.6 redd/rkm. Since surveys began in 2003 in Dry Creek redd counts have ranged from 65 to 342 redds.

During weekly redd surveys along Dry Creek in fall 2012 the highest occurrence of redds was the last survey conducted on November 27. Surveys were discontinued due to winter high flows (Figure 9.2). Spawning likely peaked in early-December and continued at least through the month. Chinook salmon spawning probably started in mid-October.

There was a disproportionate occurrence of redds between the Upper and Lower reaches of Dry Creek. The Upper Reach contained approximately four times as many redds compared to the Lower Reach during each of weekly surveys. The Upper Reach contained 82.3% of the redds on our final visit on November 27 compared to 17.7% in the Lower Reach. The Lower Reach showed a gradual increase in redd numbers during the study period suggesting that there are relatively few optimal spawning riffles in this reach, which are occupied early in the spawning season. In comparison, the Upper Reach showed substantial increases in the number of redds weekly.

Table 9. 1. Chinook salmon redd abundances by reach, upper Russian River and Dry Creek, 2002-2012. Redd counts are from a single pass survey conducted during the peak of fall spawning activity. *Survey either not completed or incomplete. Dry Creek value for 2008 is an estimate.

Reach	Reach (rkm)	Redd Observations										
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Redd Count												
Ukiah (Forks-Hwy101)	33.1	511	458	284	*	248	118	20	38	*	*	90[1]
Canyon (Hwy101-SulphurCr)	20.8	277	190	169	*	68	88	36	38	*	*	*
Alexander (SulphurCr-AV Rd)	26.2	163	213	90	*	62	131	65	129	*	97	185
Upper Healdsburg (AV Rd-Dry Cr)	25.6	79	40	8	*	23	67	48	38	*	66	53
Lower Healdsburg (Dry Cr-Wohler Bridge)	8.2	6	0	7	*	1	2	9	30	*	7	4
Russian River Subtotal	**113.9**	**1036**	**901**	**558**	*	**402**	**406**	**178**	**273**	*	**170**	**332**
Dry Creek (Dam-River)	21.7	*	256	342	*	201	231	65	223	268	229	274
Total	**135.6**		1157	900	*	603	637	243	496	268	399	606
Relative Contribution of Redds												
Russian River (%)	84.0	*	77.9	62.0	*	66.7	63.7	73.3	55.0	*	*	*
Dry Creek (%)	16.0	*	22.1	38.0	*	33.3	36.3	26.7	45.0	*	*	*

Total	100.0		100.0	100.0		100.0	100.0	100.0	100.0

[1]Redd numbers are presumably an underestimate due to poor survey conditions.

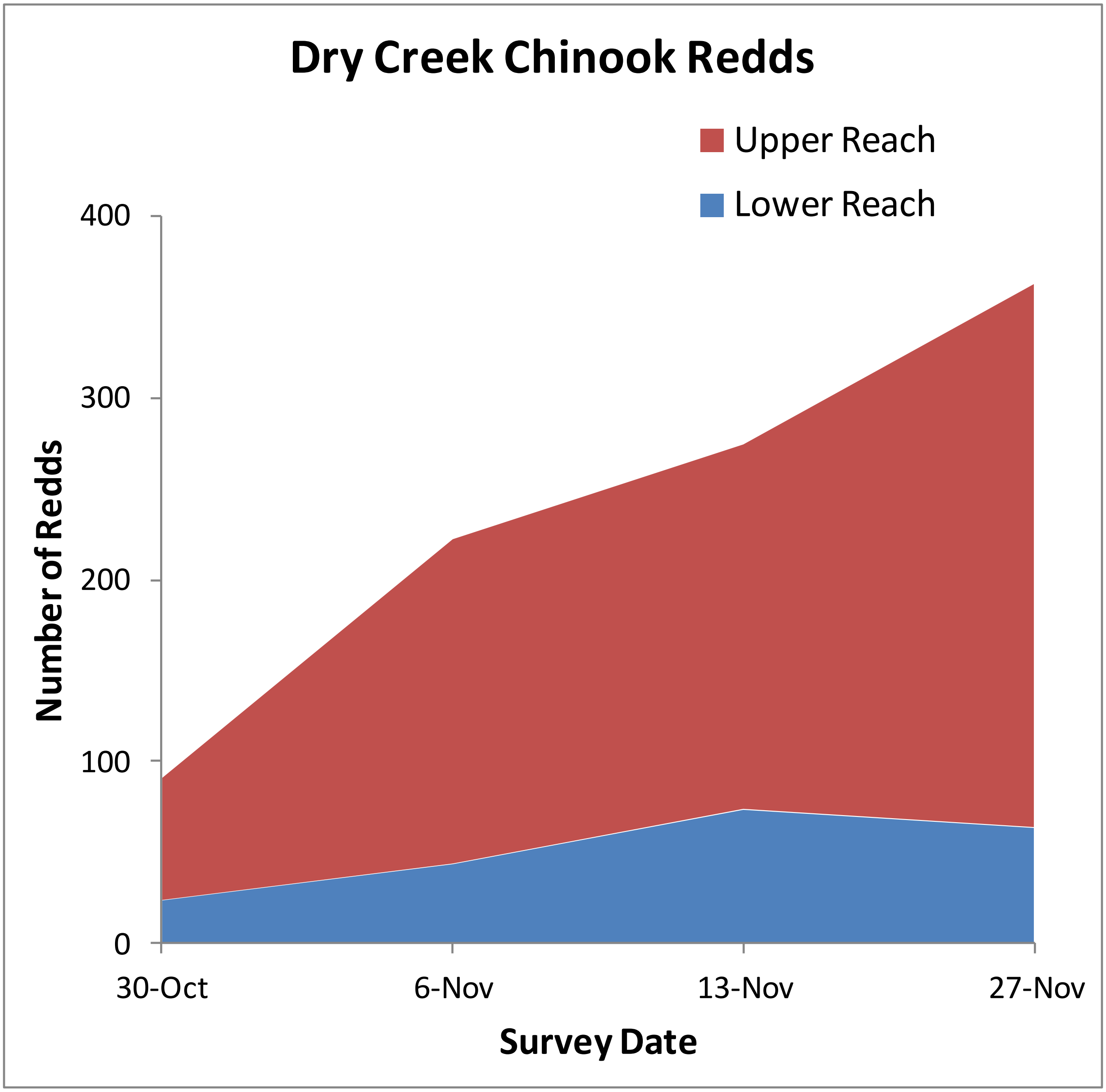

Figure 9. 2. Chinook salmon redds in reaches of Dry Creek, 2012. The number of redds observed during four weekly surveys are shown. Reaches are the upper Dry Creek from Warm Springs Dam to Lambert Bridge and lower Dry Creek from Lambert Bridge to the Russian River confluence.

Conclusions and Recommendations

In 2012, the primary Chinook salmon spawning areas in the Russian River basin were located on the mainstem from Alexander Valley upstream to Ukiah Valley and in Dry Creek, which is the same pattern observed since 2002. Redds are least abundant in the Lower Healdsburg and Upper Healdsburg reaches. The total number of redds recorded in all study reaches was 606 redds, which is presumably an underestimate due to poor survey conditions in Ukiah Reach. Based on the trend of increasing redd abundances in Dry Creek (Figure 9.2) the peak of spawning activity in the Russian River basin was likely in early December after our last survey on November 27. There were likely many more redds constructed after our surveys ended. Combined these observations suggest a large spawning run of Chinook salmon during fall 2012 and supports observations from the Mirabel Dam video monitoring of adult Chinook salmon (see Chapter 8).

References

Cook, D. (Sonoma County Water Agency). 2003. Chinook salmon spawning study, Russian River, fall 2002. 9 p. Santa Rosa, (CA): Sonoma County Water Agency.

Sonoma County Water Agency. 2011. Russian River biological opinion status and data report 2009-10. February 28. Santa Rosa (CA): Sonoma County Water Agency.

10: Synthesis

The Sonoma County Water Agency has collected a variety of fish and water quality monitoring data relevant to fulfilling the overall objectives in the Russian River Biological Opinion. Those efforts have been detailed in portions of this report leading to this chapter. The objectives specific to this synthesis chapter are to relate these data sets to one another first by illustrating the spatial and temporal extent of monitoring activities in the basin and second by presenting and discussing emerging trends in juvenile salmonid abundance, movement and growth in streams encompassed by the Reasonable and prudent Alternative (RPA) section of the Russian River Biological Opinion.

As in previous years of RPA Russian River Biological Opinion implementation, we collected data from a broad spatial (**Figure 10.1**) and temporal (**Figure 10.2**) extent in the Russian River Basin. Between April 4, 2012 and December 31, 2012, we collected fish data from multiple locations in the mainstem Russian River, Dry Creek, Mark West Creek, Dutch Bill Creek, Austin Creek and the estuary. We also conducted Chinook spawner surveys on the 119 km of stream length in mainstem Russian River between Ukiah and River front Park and four repeat Chinook spawner surveys on the 22 km of stream length in mainstem Dry Creek downstream of Warm Springs Dam. Sites, gear types, and target life stages monitored included: downstream migrant trapping with rotary screw traps on Dry Creek, mainstem Russian River at Mirabel, Mark West Creek at Trenton-Healdsburg Road and Austin Creek at the Bohan & Canelis gravel mine as well as a funnel net on Dutch Bill Creek in Monte Rio; operation of an underwater PIT antenna and underwater video camera to detect both PIT-tagged and non-PIT-tagged salmonids near the upstream extent of the tidal portion of the estuary in Duncans Mills; juvenile salmonid sampling using beach seining at ten fixed locations in the estuary; juvenile sampling using backpack electrofishing, PIT tags and PIT antennas at five sites in Dry Creek; adult Chinook surveys using underwater video at Mirabel. Complementary data on water quality were collected by means of continuously-recording datasondes at 10 sites throughout the estuary/lagoon and from bi-weekly and weekly grab samples at five additional sites. Details regarding the specifics of these monitoring activities are covered in individual chapters of this report.

Figure 10.1. Spatial extent of fisheries and water quality monitoring related to the Russian River Biological Opinion, 2012.

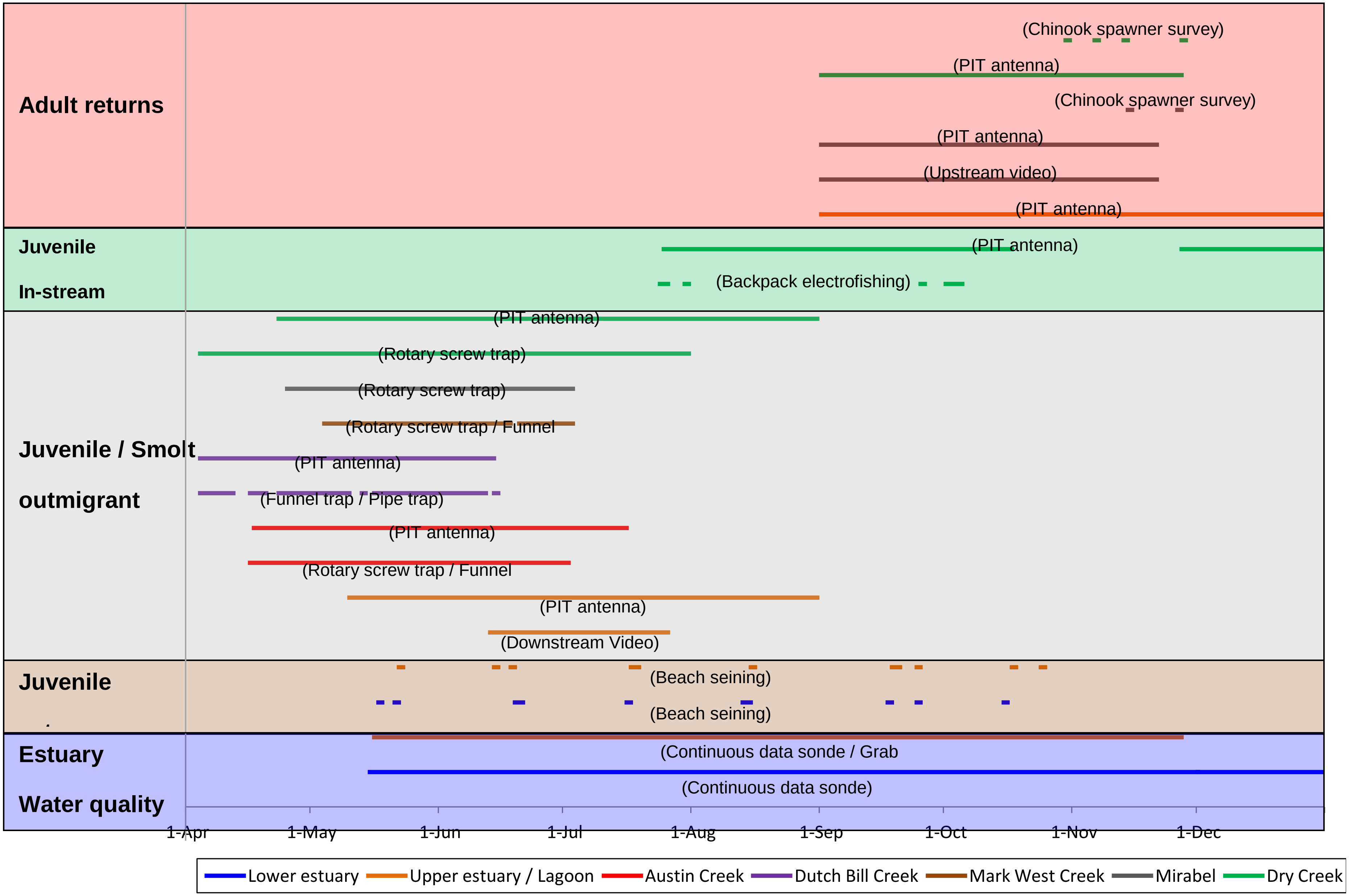

Figure 10.2. **Temporal and life stage extent of sampling at fisheries and water quality monitoring sites related to the Russian River Biological Opinion, 2012.**

In the sections that follow, we summarize abundance, movement and growth dynamics of juvenile and smolt salmonids based on data from tributary and mainstem sites sampled in 2012. The Water Agency used PIT tags and fin-clipping as primary tools for characterizing these metrics. As described in other sections of this report and reports from prior years, PIT-tagged and/or fin-clipped fish were detected at downstream trapping locations and during beach seining sampling bouts in the estuary as well as at downstream migrant traps and stationary PIT-tag antennas located throughout the system (Figure 10.1). In the first section below, we broadly summarize available abundance information to describe some general temporal trends in abundance and variability in abundance. Following that, we focus specifically on the movement of juvenile steelhead from the Mirabel trap site on the mainstem Russian River and “lower river tributaries” (i.e., Mark West Creek, Dutch Bill Creek, Austin Creek) into the lower mainstem and estuary. Next we describe efforts based on a combination of PIT tags and site-specific fin-clipping (upper caudal clip at Dry Creek and lower caudal clip at Mirabel) to evaluate Chinook smolt migration from the downstream migrant trap on Dry Creek to the Mirabel inflatable dam on the mainstem Russian River- a distance of approximately 27 km. We also gathered initial data on the timing of Chinook smolt movement from the Mirabel dam to the upstream extent of the tidal portion of the Russian River estuary in Duncans Mills- a distance of approximately 28 km. We conclude by matching data from 2012 fish sampling to water temperature and dissolved oxygen data collected at fixed sampling sites in the estuary.

Abundance

Combined juvenile steelhead capture at Dry Creek, Mirabel, Dutch Bill Creek and Austin Creek was higher in 2012 than any of the four years of downstream migrant trapping (2009-2012) at these sites; most of that increase is attributable to Dry and Austin Creeks (Table 10.1). When compared to 2011, indications in 2012 are that juvenile steelhead numbers decreased slightly in Austin Creek and the estuary but perhaps increased slightly in mainstem Dry Creek (Figure 1). Chinook smolt estimates were remarkably similar between 2011 and 2012 in Dry Creek but decreased sharply at Mirabel and in the estuary and captures of wild coho showed modest increases (Figure 1). Juvenile trends roughly matched trends for coho, but the juvenile trend did not necessarily match the juvenile trend for steelhead or Chinook (Figure 2). The reasons for this variability are likely related to environmental factors that may be unfavorable for pre-smolt survival.

Table 10.1. Number of individual salmonids captured by life stage at downstream migrant traps operated by the Water Agency, 2009-2012.

		Juvenile			Smolt			
		Steelhead	Coho salmon		Steelhead	Coho salmon		Chinook salmon
Year	Tributary	Wild	Wild	Hatchery	Wild	Wild	Hatchery	Wild
2009	Dry Creek	5,258	0	0	219	3	7	21,724
	Mainstem	75	0	0	33	5	208	1,399
	Total	***5,333***	***0***	***0***	***252***	***8***	***215***	***23,123***
2010	Dry Creek	2,049	2	0	33	1	19	5,241
	Mainstem	375	0	0	42	1	180	2,368
	Green Valley Creek	67	0	0	27	0	0	0
	Dutch Bill Creek	58	0	39	5	1	184	4
	Austin Creek	4,774	0	1,906	232		103	24
	Total	***7,323***	***2***	***1,945***	***339***	***3***	***486***	***7,637***
2011	Dry Creek	2,879	18	0	72	83	113	20,917
	Mainstem	528	10	0	151	15	872	13,753
	Green Valley Creek	3	1	0	1	2	229	16
	Dutch Bill Creek	31	5	0	47	0	2,904	34
	Austin Creek	1,829	14	45	175	0	335	48
	Total	***5,270***	***48***	***45***	***446***	***100***	***4,453***	***34,768***
2012	Dry Creek	4,706	35	0	56	117	127	8,145
	Mainstem	984	45	0	78	26	270	2,428
	Mark West Creek	95	7	0	44	28	357	376
	Dutch Bill Creek	21	0	0	11	35	1,952	13
	Austin Creek	3,672	372	584	164	37	507	377
	Total	***9,478***	***459***	***584***	***353***	***243***	***3,213***	***11,339***

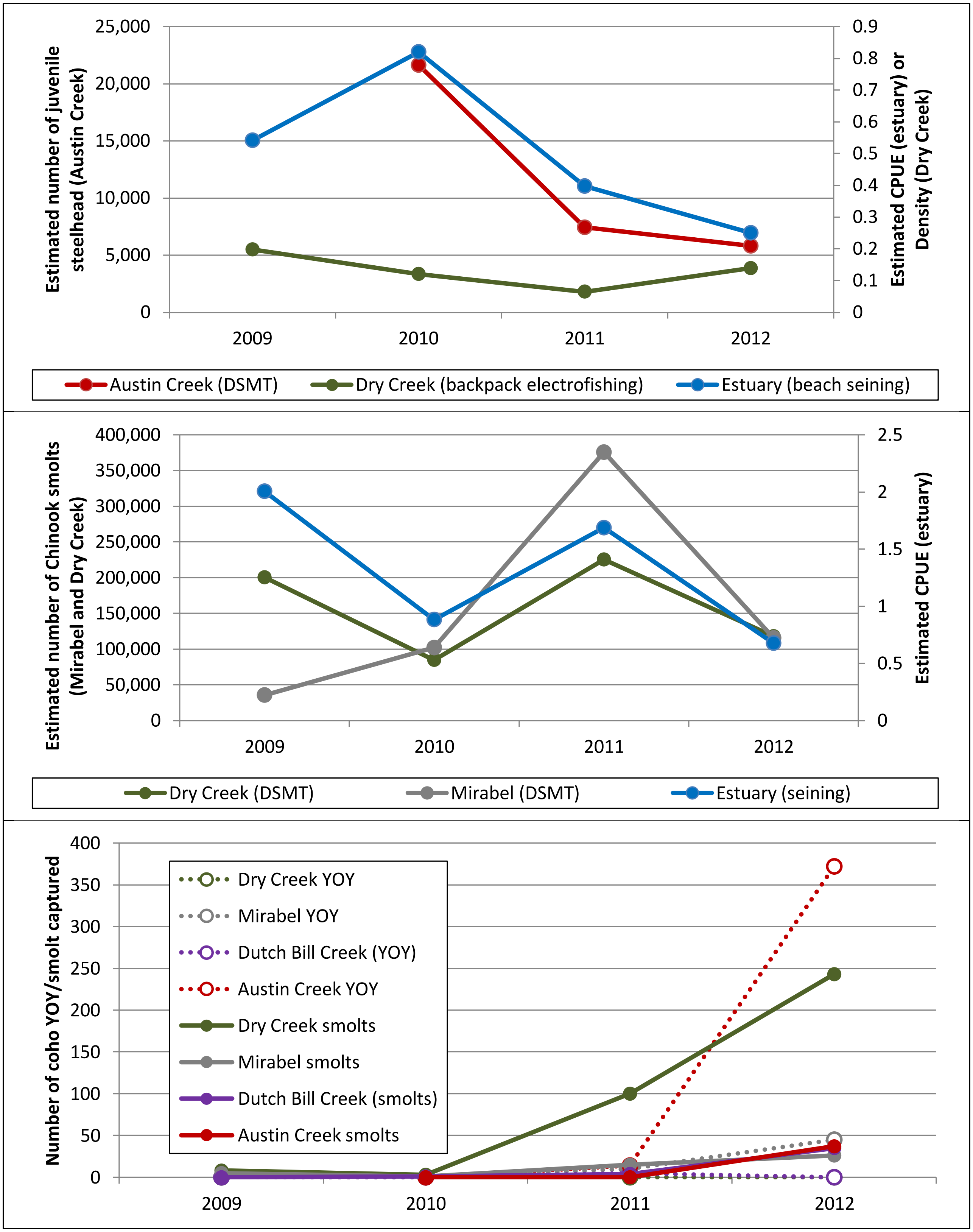

Figure 1. **Indicators of juvenile steelhead (top panel), Chinook smolts (middle panel) and wild coho smolt/YOY trends based on monitoring conducted by the Water Agency, 2009-2012.**

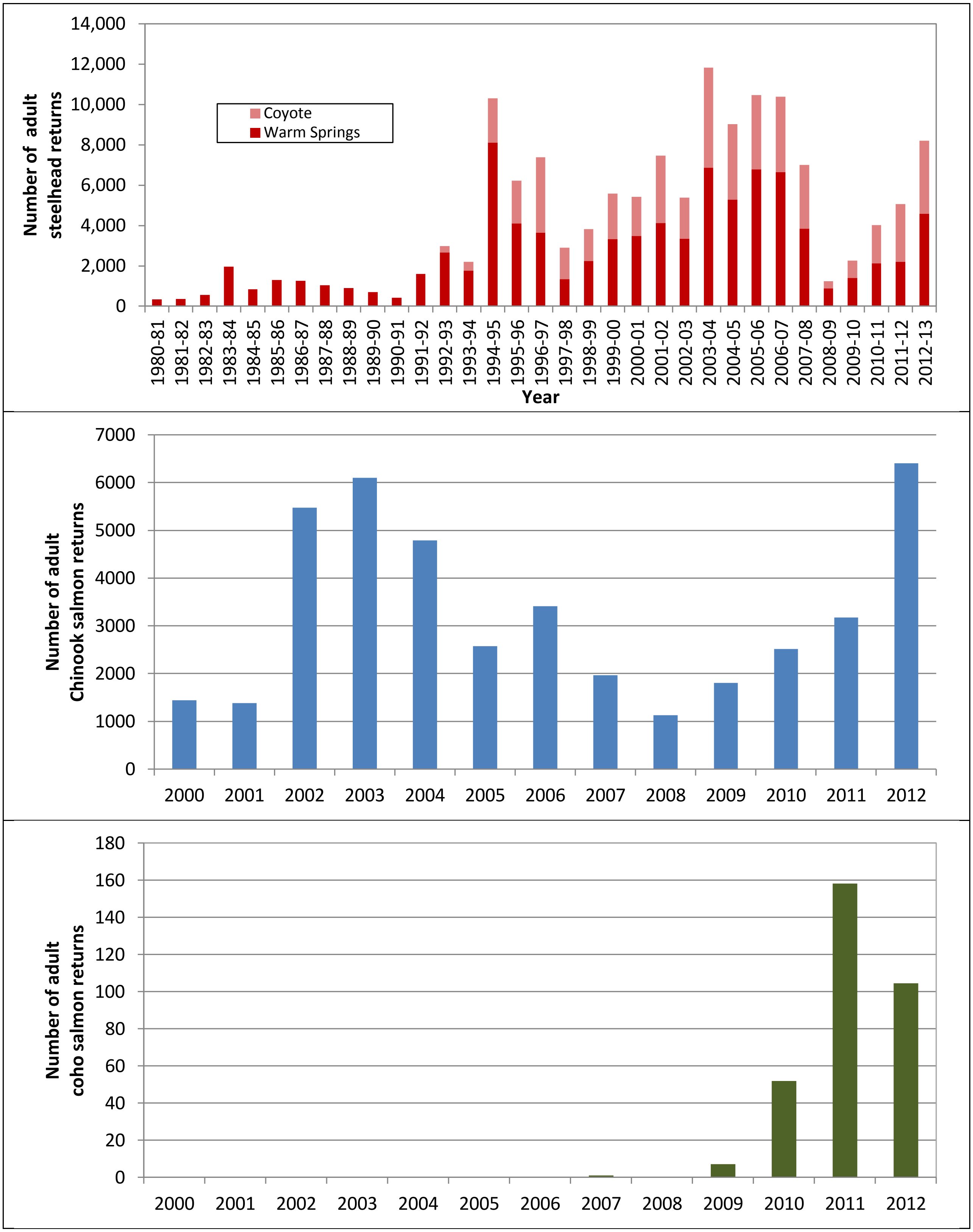

Figure 2. **Indicators of adult steelhead (counted at Russian River hatcheries) and adult Chinook and coho salmon returns (based on underwater video counts at Mirabel).**

Juvenile steelhead and Chinook salmon movement and growth

In 2012, we PIT-tagged 2,863 individual juvenile steelhead at all sites combined (Table 10.2). We later gathered detection information on a portion of these individuals (Table 10.3) to help inform us about growth (Table 10.4, Figure 10.3) and transit time (Table 10.4) within and among various portions of the estuary, mainstem, lower River tributaries and Dry Creek.

In 2012 we continued to observe high juvenile steelhead growth rates for fish reared in the estuary (Figure 10.3) as well as movement of a significant proportion (50%) of steelhead out of lower Austin Creek and into the estuary. Based on detections at the Duncans Mills PIT antenna array, the rate of movement was rapid (median<2 days, n=252) just as it has been in previous years. Other than Austin Creek, we did not detect or capture any of the juvenile steelhead PIT-tagged at an upstream trap site in the estuary during seining or as they transitioned into the estuary at the PIT antenna site in Duncans Mills; however, only 364 juvenile steelhead were PIT tagged at Mirabel, Dutch Bill and Mark West traps, combined as compared to 1,459 at the Austin Creek trap.

Table 10.2. Number of juvenile steelhead that were PIT-tagged and observed with a PIT-tag at all Water Agency fish capture sites, 2009-12.

Tributary	Survey	Year	Applied	Observed
Dry Creek	Electrofishing	2009	823	104
		2010	897	168
		2011	801	140
		2012	775	202
Mainstem	Downstream migrant trap	2009	17	0
		2010	96	51
		2011	99	1
		2012	315	3
Mark West Creek	Downstream migrant trap	2012	43	0
Dutch Bill Creek	Downstream migrant trap	2010	46	0
		2011	23	1
		2012	6	0
Austin Creek	Downstream migrant trap	2010	997	113
		2011	500	30
		2012	1,639	568
Estuary	Beach seining	2009	68	4
		2010	241	41
		2011	88	18
		2012	85	15
		Total	***7,559***	***1,459***

Table 10.3. Number of PIT-tagged juvenile steelhead detected at various sites by location of tagging. Shaded numbers on diagonal indicate recapture /detection at the same site. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.

DETECTION / TAGGING SITE			RECAPTURE SITE: Estuary				Austin Creek		Dutch Bill Creek	Mark West Creek	Mainstem	Dry Creek				
			Lower reach	Middle reach	Upper reach		Steel bridge	Gravel mine	Smolt trap	Lower smolt	Mirabel	Lower reach		Middle reach		Upper reach
			Seining	Seining	PIT antenna	Seining	PIT antenna	DSMT	DSMT	DSMT	DSMT	PIT antenna	Efishing	PIT antenna	Efishing	Efishing
Estuary	Lower reach	Seining	5													
	Middle reach	Seining		0												
	Upper reach	PIT antenna			na	19										
		Seining				0										
Austin Creek	Steel bridge	PIT antenna														
	Gravel mine	DSMT	3	1	252	1	562	250								
Dutch Bill Creek	Monte Rio Park	DSMT							0							

Mark West Creek	Trenton-Healdsburg	DSMT								0						
Mainstem	Mirabel	DSMT									3					
Dry Creek	Lower reach	PIT antenna										na				
		Efishing										62	57			
	Middle reach	PIT antenna												na		
		Efishing												32	85	
	Upper reach	Efishing														14

Table 10.4. Mean individual growth rates (mm per day) of juvenile steelhead captured and tagged in 2012 and later recaptured in 2012. Numbers in parentheses represent sample sizes. Tributaries and sites are sorted from downstream to upstream (top to bottom and left to right) so numbers below diagonal indicate downstream movement while numbers above diagonal indicate upstream movement.

DETECTION / TAGGING SITE			RECAPTURE SITE						
			Estuary			Austin Creek	Dry Creek		
			Lower reach	Middle reach	Upper reach	Gravel mine	Lower reach	Middle reach	Upper reach
			Seining	Seining	Seining	DSMT	Electrofishing	Electrofishing	Electrofishing
Estuary	Lower reach	Seining	1.04 (5)						
	Middle reach	Seining		No recaptures					
	Upper reach	Seining			No recaptures				
Austin	Gravel mine	DSMT	0.78 (3)	0.52 (1)	1.8 (1)	na			
Dry Creek	Lower reach	Electrofishing					0.31 (29)		
	Middle reach	Electrofishing						0.39 (41)	
	Upper reach	Electrofishing							0.32 (9)

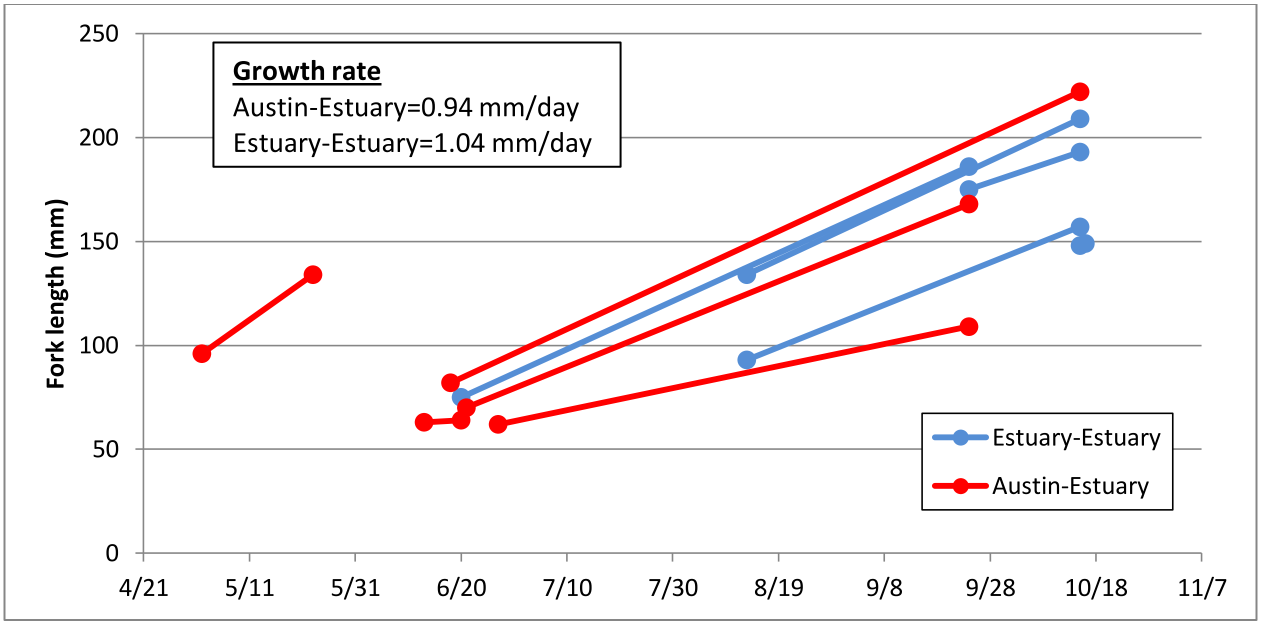

Figure 10.3. **Fork lengths of individual PIT-tagged juvenile steelhead that were initially caught at the Austin Creek downstream migrant trap then later recaptured while beach seining in the estuary or initially captured while beach seining in the estuary then recaptured later while beach seining in the estuary.**

Chinook smolt migration

In Manning and Martini-Lamb (2012), we described the importance of gaining an understanding of sources of smolt mortality as fish make their seaward migration. This understanding is particularly important in light of changes in flows and estuary management that are now being implemented as part of the RPA. The initial approach in 2011 and continued here with the 2012 data is to focus on Chinook salmon mortality between the downstream migrant trap on Dry Creek at Westside Road and the Russian River downstream migrant trap at Mirabel (a distance of approximately 27 km). By using PIT-tagged fish and the PIT antenna station at Duncans Mills (Figure 10.1), this same approach could be used to similarly model mortality through the lower mainstem (downstream of Mirabel) for not just Chinook smolts, but perhaps coho smolts as well.

The evaluation is based on differences in rates of capture at Mirabel of two groups of Chinook salmon smolts: a Mirabel-marked group and a Dry Creek-marked group. The Mirabel group was made up of 1,777 fish initially captured at the Mirabel trap, lower-caudal-clipped and released in Wohler pool approximately 1 km upstream of the trap between April 25 and July 2. A total of 114 of these fish (6.4%) were recaptured at the Mirabel trap between April 26 and July 3. The Dry Creek group was made up of 2,693 fish initially captured at the Dry Creek trap, upper-caudal-clipped and released back into Dry Creek between April 25 and July 2. A total of 101 of these fish (3.75%) were subsequently captured at the Mirabel trap. That means that under a scenario of similar migration mortality for the two groups (Wohler pool to Mirabel vs. Dry Creek to Mirabel) we would expect to capture 6.4% of the entire population emigrating from Dry Creek at

Mirabel yet we only captured 3.75%. Put another way, for every 1,000 fish leaving Dry Creek we should expect to have captured 64 at Mirabel yet we only captured 38 (a 41% reduction). This reduction is remarkably similar to the reduction calculated for the 2011 season (44%).

The change in composition of the Chinook smolt run at Mirabel that originated in Dry Creek vs. mainstem Russian River is a factor that could influence overall survival of a given cohort through that portion of the river between the Dry Creek confluence and the Mirabel Dam. We examined weekly average size as a way to discern that composition (Figure 10.4). When compared to the mainstem Russian River, Dry Creek water temperatures were cooler during the Chinook smolt migration season (Figure 10.5) and that this is always the case because of the coldwater releas from Lake Sonoma. We suggest that this difference in temperature is a key contributor to the differences in size observed between the two sites early in the smolt season and can also underlie the difference in run-timing between the two sites in some years (Figure 10.6, 2009 and 2011). We hypothesize that the similarity in both body size and run timing at the two sites in 2012 is accounted for by less of a contribution from mainstem Russian River-produced fish as compared to Dry Creek for some reason.

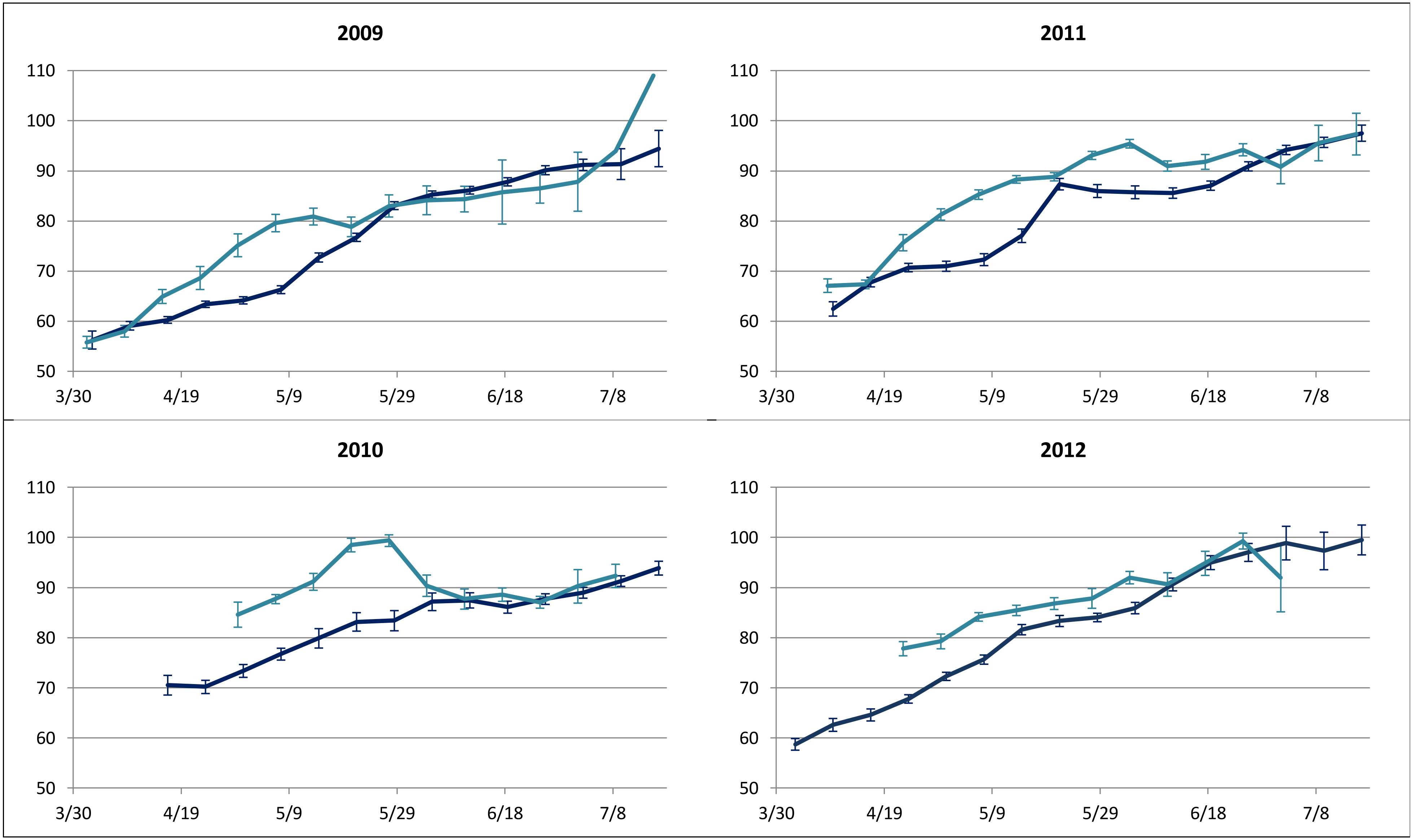

Figure 10.4. Weekly mean fork length (±95% CI) of Chinook salmon from 2009-2012 captured at the Dry Creek downstream migrant trap (dark blue line) and Mirabel downstream migrant trap (light blue line).

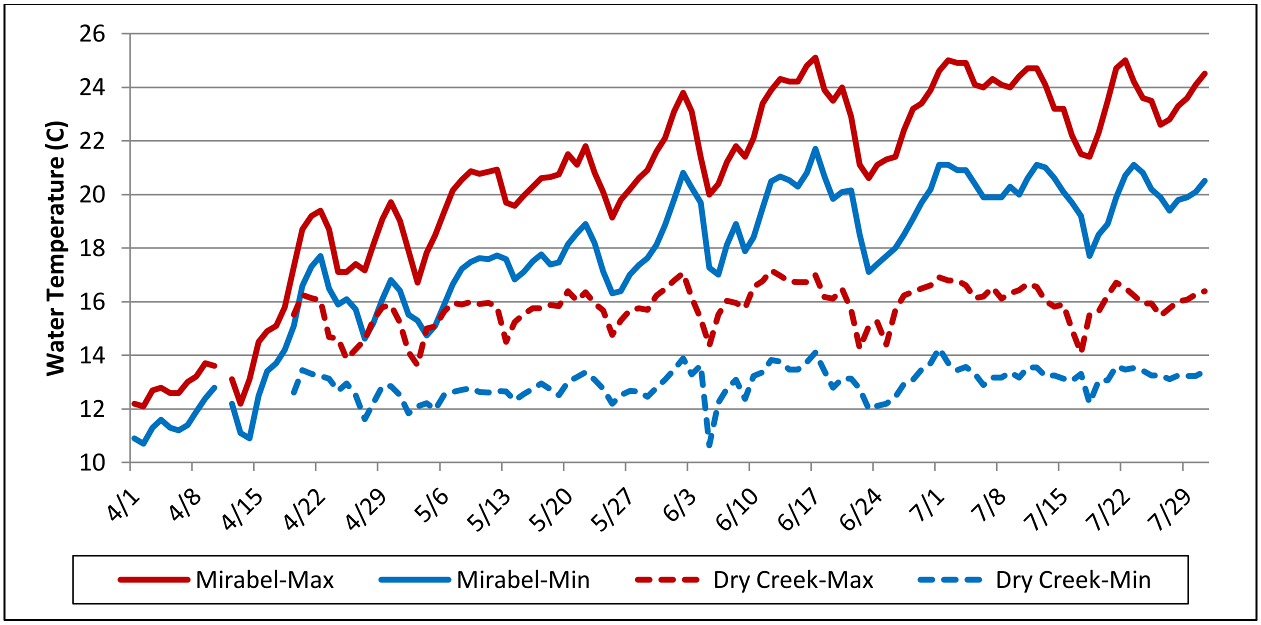

Figure 10.5. Daily minimum and maximum water temperatures in Dry Creek (downstream migrant trap, Westside Road) and mainstem Russian River (USGS gage at Hacienda).

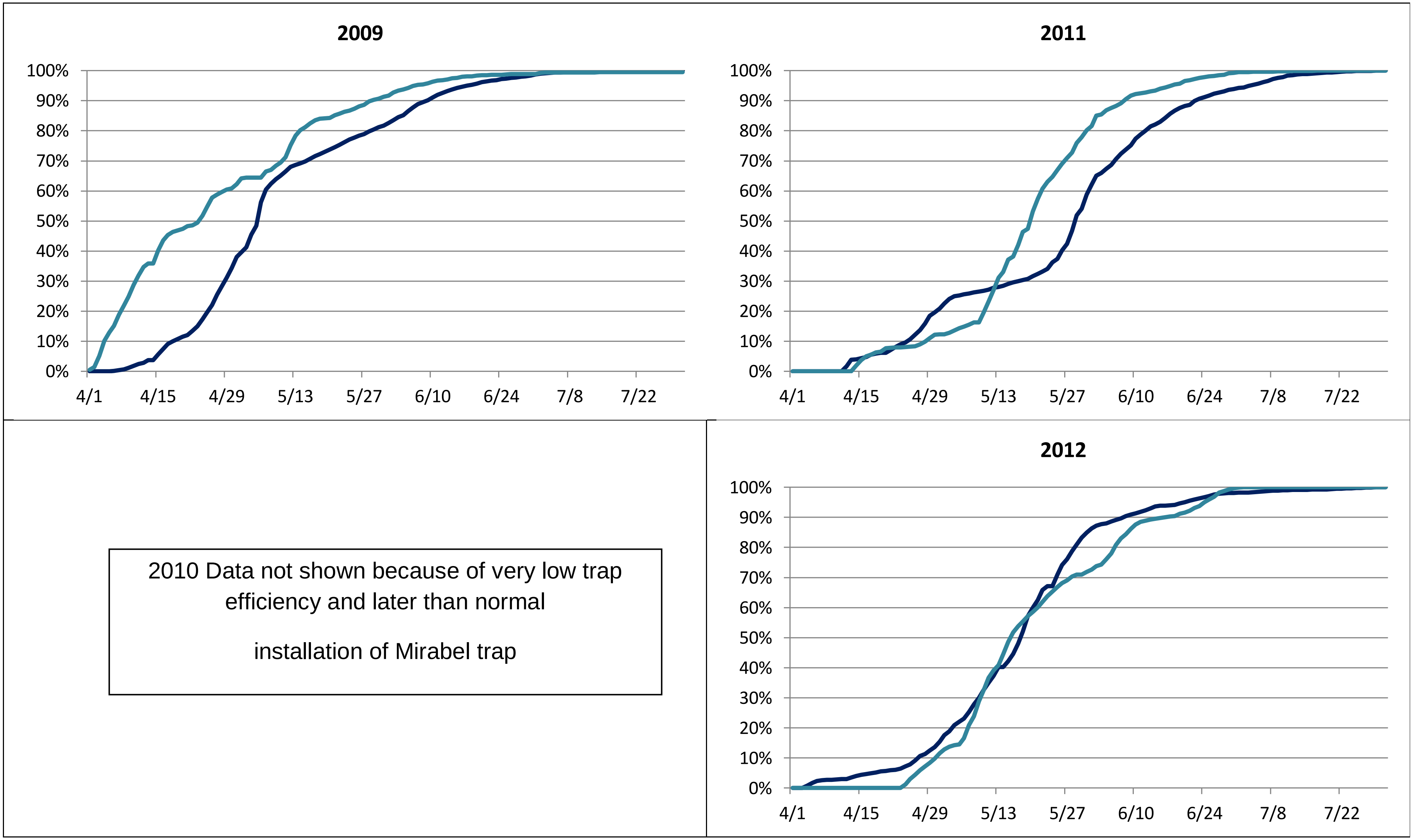

Figure 10.6. Cumulative daily capture of Chinook salmon 2009, 2011 and 2012 captured at the Dry Creek downstream migrant trap (dark blue line) and Mirabel downstream migrant trap (light blue line).

Salmonid movement and estuarine conditions

In past reports as well as in other sections of this report, we have discussed some of the limitations that come with attempting to relate various water quality constituents with fish presence data. Many of the issues arise because of a mismatch in the spatial scale of the data being collected as well as the fact that conditions in the estuary are extremely dynamic and are influenced by a host of factors that are themselves highly dynamic and interact in complex ways. Despite this mismatch of scale, we continue to pair the water quality and fish data because of the clear influence water quality constituents such as temperature and dissolved oxygen have on salmonid ecology.

We selected hourly records of water quality (temperature and dissolved oxygen) collected in Villa Grande (the freshwater portion of the area of the mainstem Russian that backwaters during mouth closure) and Patty's Rock (lower estuary) to represent water quality conditions in the portion of the river affected during river mouth closure. We apply thresholds for water temperature and dissolved oxygen (Table 10 5) to our data, then show the data in relation to timing of fish capture at upstream trapping sites (Austin Creek, Mirabel, Dry Creek) as a way to illustrate conditions that were likely encountered by juvenile steelhead, coho smolts and Chinook smolts as they moved through the lower mainstem and estuary in 2012.

Table 10 5. Temperature and dissolved oxygen thresholds used for ranking observed estuarine water quality for rearing salmonids in 2010. Temperature thresholds are based on Sullivan et al. (2000) and NCRWQCB (2000).

Quality	Maximum weekly average temperature (˚C)	Dissolved oxygen (mg/l)
Excellent	13-17	7-12
Good	17-19	5-8
Poor	19-24	3-5
Very poor	>24	<3

We evaluated seven day running average water temperature in the "backwater area" (Villa Grande, RiverKm=13.9) and the lower estuary (Patty's Rock, RiverKm=2.5) in combination with the juvenile steelhead and salmon smolt cumulative catch curves from upstream capture sites (Figure 10.7). From this evaluation, fish moving downstream during the early portion of the season (prior to June 1) likely encountered favorable water temperatures in the backwater area but relatively unfavorable water temperatures during the latter portion of the season (after June 1) while in the lower portion of the estuary water temperatures were less favorable throughout the period. Good to excellent dissolved oxygen conditions prevailed throughout the migration period at both locations. The general patterns observed in 2012 are consistent with patterns in previous years suggesting that early movers may have lower acute mortality as they move through the estuary as compared to later movers. However, we also hypothesize that of the late movers that do survive they may have a growth advantage over early movers because of these warmer temperatures. This may be particularly the case for juvenile steelhead. Indeed, some of the juvenile steelhead growth rates we have reported are quite high (~1 mm/day) but to date our monitoring approach is insufficient for making comparisons in either growth or survival between early and late movers. However, our data do support the extreme importance of considering estuarine water quality when contemplating changes to estuary management that are intended to benefit juvenile salmonids.

Conclusions and Recommendations

In 2012, the Water Agency continued to refine methods and approaches for gathering the information necessary to inform the decisions as the RPA is implemented. As the Water Agency continues to implement the Russian River Biological Opinion, information on abundance, movement and growth will be instrumental to our understanding of how various management actions outlined in the RPA translate to benefits for salmonid populations in the Russian River.

The PIT monitoring program employed by the Water Agency and the University of California Cooperative Extension / Sea Grant are proving to be key tools for overcoming the limitations posed by more traditional sampling methods (e.g., snorkeling, electrofishing, adult traps) that are impossible or problematic to implement in certain portions of the watershed covered by the RPA. We look forward to expanding our network of PIT antenna monitoring capabilities in the future- particularly at our estuary PIT antenna station at Duncans Mills. We are also evaluating ways to take a broader look at accounting for population-level processes outside of the influence of the Water Agency that are, nevertheless, impacting the steelhead and salmon populations we are working with and therefore should be accounted for when evaluating progress from RPA-implementation. One such example is implementation of the California Coastal Monitoring Plan (Adams et al. 2011) that the Water Agency and UC will begin implementing in the Russian River beginning in 2013.

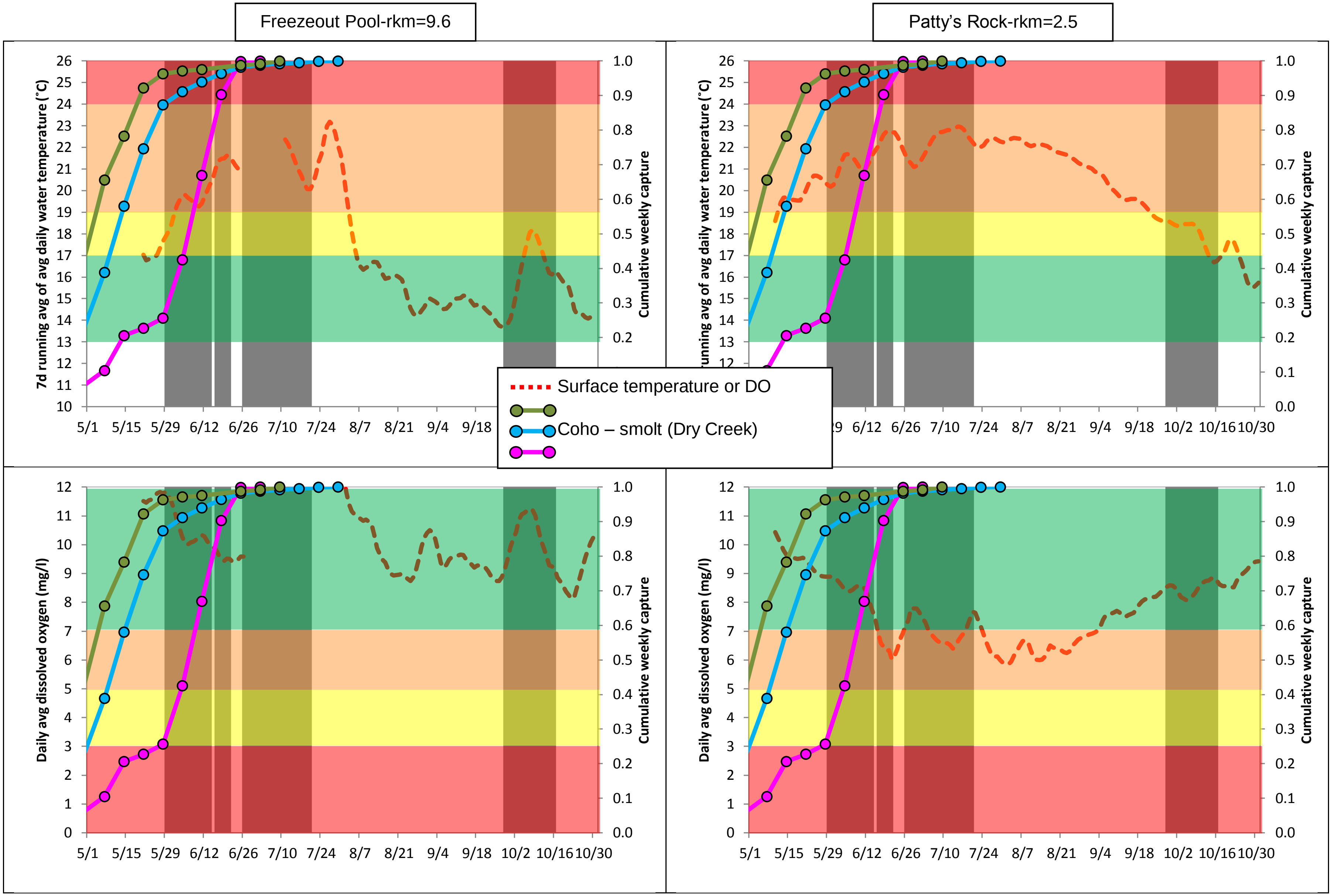

Figure 10.7. Seven day running average of daily average water temperature (upper panels) and average daily dissolved oxygen (lower panels) at Villa Grande (backwater area, see text) and Patty's Rock (lower estuary). Salmonid capture is from representative sites in the basin. Horizontal shaded areas correspond to literature-based criteria (see Table 10 5) and shaded vertical areas depict periods when the estuary was closed.

An area of our monitoring that is particularly important to develop is an improved approach for evaluating the habitat use (especially water quality) in the estuary. We are aware that limitations in our current monitoring approach are impacting our ability to adequately inform decisions regarding future estuary management. Some additional approaches we are exploring include acoustic tags with an onboard temperature sensor that can be implanted in fish as small as 100 mm.

References

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Appendices

See include compact disc for appendices.